AF
#
3626
#13
SS
10/14/01

Please type a plus sign (+) inside this box → +

PTO/SB/21 (08-00)
Approved for use through 10/31/2002. OMB 0651-0031
U.S. Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

TRANSMITTAL FORM

(to be used for all correspondence after initial filing)

Total Number of Pages in This Submission: 107

Application Number	09/369,134
Filing Date	08/05/1999
First Named Inventor	Oran D. Tarlton
Group Art Unit	3626
Examiner Name	V. Patel
Attorney Docket Number	LTVA:102/AUC

ENCLOSURES *(check all that apply)*

- [X] Fee Transmittal Form
  - [X] Fee Attached
- [ ] Amendment / Reply
  - [ ] After Final
  - [ ] Affidavits/declaration(s)
- [ ] Extension of Time Request
- [ ] Express Abandonment Request
- [ ] Information Disclosure Statement
- [ ] Certified Copy of Priority Document(s)
- [ ] Response to Missing Parts/ Incomplete Application
  - [ ] Response to Missing Parts under 37 CFR 1.52 or 1.53
- [ ] Assignment Papers *(for an Application)*
- [ ] Drawing(s)
- [ ] Licensing-related Papers
- [ ] Petition
- [ ] Petition to Convert to a Provisional Application
- [ ] Power of Attorney, Revocation Change of Correspondence Address
- [ ] Terminal Disclaimer
- [ ] Request for Refund
- [ ] CD, Number of CD(s) _____
- [ ] After Allowance Communication to Group
- [ ] Appeal Communication to Board of Appeals and Interferences
- [X] Appeal Communication to Group *(Appeal Notice, Brief, Reply Brief)*
- [ ] Proprietary Information
- [ ] Status Letter
- [X] Other Enclosure(s) *(please identify below)*:

-Appellant's Brief Per 37 C.F.R. Section 1.192 (filed in triplicate)
-CHECK ($310.00)
- Return Receipt Postcard

Remarks

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT

Firm or Individual name	Richard C. Auchterlonie, Esq., Reg. No. 30,607 **Howrey Simon Arnold & White, LLP**
Signature	Richard C. Auchterlonie
Date	26 Sept. 2001

CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited with the United States Postal Service with sufficient postage as first class mail in an envelope addressed to: Commissioner for Patents, Washington, DC 20231 on this date: 26 Sep. 2001

Typed or printed name	Richard C. Auchterlonie, Esq., Reg. No. 30,607		
Signature	Richard C. Auchterlonie	Date	26 Sept. 2001

PTO/SB/17 (11-00)
Approved for use through 10/31/2002. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

FEE TRANSMITTAL for FY 2001

Patent fees are subject to annual revision.

TOTAL AMOUNT OF PAYMENT ($) 310

Complete if Known	
Application Number	09/369,134
Filing Date	08/05/1999
First Named Inventor	Oran D. Tarlton
Examiner Name	V. Patel
Group Art Unit	3626
Attorney Docket No.	LTVA:102/AUC

METHOD OF PAYMENT

1. [X] The Commissioner is hereby authorized to charge indicated fees and credit any overpayments to:
   Deposit Account Number: 01-2508 /LTVA:102
   Deposit Account Name: Howrey Simon Arnold & White, LLP
   [X] Charge Any Additional Fee Required Under 37 CFR 1.16 and 1.17
   [ ] Applicant claims small entity status. See 37 CFR 1.27

2. [X] **Payment Enclosed:**
   [X] Check [ ] Credit card [ ] Money Order [ ] Other

FEE CALCULATION

1. BASIC FILING FEE

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
101	710	201	355	Utility filing fee	
106	320	206	160	Design filing fee	
107	490	207	245	Plant filing fee	
108	710	208	355	Reissue filing fee	
114	150	214	75	Provisional filing fee	

SUBTOTAL (1) ($)

2. EXTRA CLAIM FEES

	Extra Claims		Fee from below		Fee Paid
Total Claims		-20** =		X	=
Independent Claims		- 3** =		X	=
Multiple Dependent					=

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description
103	18	203	9	Claims in excess of 20
102	80	202	40	Independent claims in excess of 3
104	270	204	135	Multiple dependent claim, if not paid
109	80	209	40	** Reissue independent claims over original patent
110	18	210	9	** Reissue claims in excess of 20 and over original patent

SUBTOTAL (2) ($)

**or number previously paid, if greater; For Reissues, see above

FEE CALCULATION (continued)

3. ADDITIONAL FEES

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
105	130	205	65	Surcharge - late filing fee or oath	
127	50	227	25	Surcharge - late provisional filing fee or cover sheet	
139	130	139	130	Non-English specification	
147	2,520	147	2,520	For filing a request for *ex parte* reexamination	
112	920*	112	920*	Requesting publication of SIR prior to Examiner action	
113	1,840*	113	1,840*	Requesting publication of SIR after Examiner action	
115	110	215	55	Extension for reply within first month	
116	390	216	195	Extension for reply within second month	
117	890	217	445	Extension for reply within third month	
118	1,390	218	695	Extension for reply within fourth month	
128	1,890	228	945	Extension for reply within fifth month	
119	310	219	155	Notice of Appeal	
120	310	220	155	Filing a brief in support of an appeal	310
121	270	221	135	Request for oral hearing	
138	1,510	138	1,510	Petition to institute a public use proceeding	
140	110	240	55	Petition to revive - unavoidable	
141	1,240	241	620	Petition to revive - unintentional	
142	1,240	242	620	Utility issue fee (or reissue)	
143	440	243	220	Design issue fee	
144	600	244	300	Plant issue fee	
122	130	122	130	Petitions to the Commissioner	
123	50	123	50	Processing fee under 37 CFR 1.17(q)	
126	180	126	180	Submission of Information Disclosure Stmt	
581	40	581	40	Recording each patent assignment per property (times number of properties)	
146	710	246	355	Filing a submission after final rejection (37 CFR § 1.129(a))	
149	710	249	355	For each additional invention to be examined (37 CFR § 1.129(b))	
179	710	279	355	Request for Continued Examination (RCE)	
169	900	169	900	Request for expedited examination of a design application	

Other fee (specify) _____

*Reduced by Basic Filing Fee Paid **SUBTOTAL (3)** ($) 310

SUBMITTED BY				Complete (if applicable)	
Name (Print/Type)	Richard C. Auchterlonie, Esq.	Registration No. (Attorney/Agent)	30,607	Telephone	713.787.1698
Signature	Richard C. Auchterlonie			Date	26 Sept. 2001

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

Burden Hour Statement: This form is estimated to take 0.2 hours to complete. Time will vary depending upon the needs of the individual case. Any comments on the amount of time you are required to complete this form should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, Washington, DC 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Assistant Commissioner for Patents, Washington, DC 20231.

#13
88
10/14/01

CERTIFICATE OF MAILING
37 C.F.R. 1.8

I hereby certify that this correspondence is being deposited with the U.S. Postal Service with sufficient postage as First Class Mail in an envelope addressed to: Commissioner for Patents, Washington, DC 20231, on the date below:

26 Sept. 2001
Date

Signature Reg. 30,607

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:
Oran D. Tarlton

Serial No.: 09/369,134

Filed: August 5, 1999

For: COMPOSITE METAL-TO-METAL SEAL HAVING A RELATIVELY SOFT METAL OVERLAY AND A RELATIVELY HARD METAL CORE

Group Art Unit: 3626

Examiner: V. Patel

Atty. Dkt. No.: LTVA:102/AUC

APPELLANT'S BRIEF PER 37 C.F.R. § 1.192

Commissioner for Patents
Washington, D.C. 20231

Sir:

This appeal brief, filed in triplicate, is in support of Appellant's appeal filed on July 27, 2001. Please find enclosed a check for $310.00 for filing this appeal brief. Please deduct any deficiency in the fee from Howrey Simon Arnold & White Deposit Account No. 01-2508, Order No. LTVA:102.

I. Real Party in Interest

The real party in interest is Oil States Industries, Incorporated, by virtue of an assignment from the inventor recorded at Reel 010155, Frame 0504.

II. Related Appeals and Interferences.

There are no related appeals or interferences.

III. Status of the Claims.

Claims 1 to 26 have been presented for examination.

Claims 15 to 20 have been withdrawn from consideration and have been cancelled;

Claims 1 to 14 and 21 to 26 stand finally rejected, and are being appealed.

IV. Status of Amendments.

A final amendment was filed on July 27, 2001. An advisory action dated Aug. 3, 2001 indicates that the proposed amendment will be entered upon the timely submission of a Notice of Appeal and Appeal Brief with requisite fees.

V. Summary of Invention.

The invention relates generally to a pressure seal for containing fluid pressure at an annular interface having a metal-to-metal contact with one or more metal annular members. (Specification, page 2, lines 8 to 11.) In particular, it is desired to make a proper metal-to-metal seal in a pipe connector of the kind that forms a pressure seal by wedging a metal seal ring between two hubs, and to permit the metal-to-metal seal to be broken and later properly reset. (Specification, page 2, lines 17 to 20 and page 3, lines 6 to 10.)

To solve these problems, there is provided a composite metal seal (15) that includes a core (34) of relatively hard metal, and at least one annular region (35, 36) of relatively soft metal. The annular region of relatively soft metal is integrally bonded with the core of relatively hard

metal, and has an annular sealing surface (32, 33) for providing a fluid pressure seal. (Specification, page 4, lines 19 to 24; page 13 line 23 to page 14 line 10; FIG. 3.) The composite metal seal (15) is shown in FIG. 3, as reproduced below:

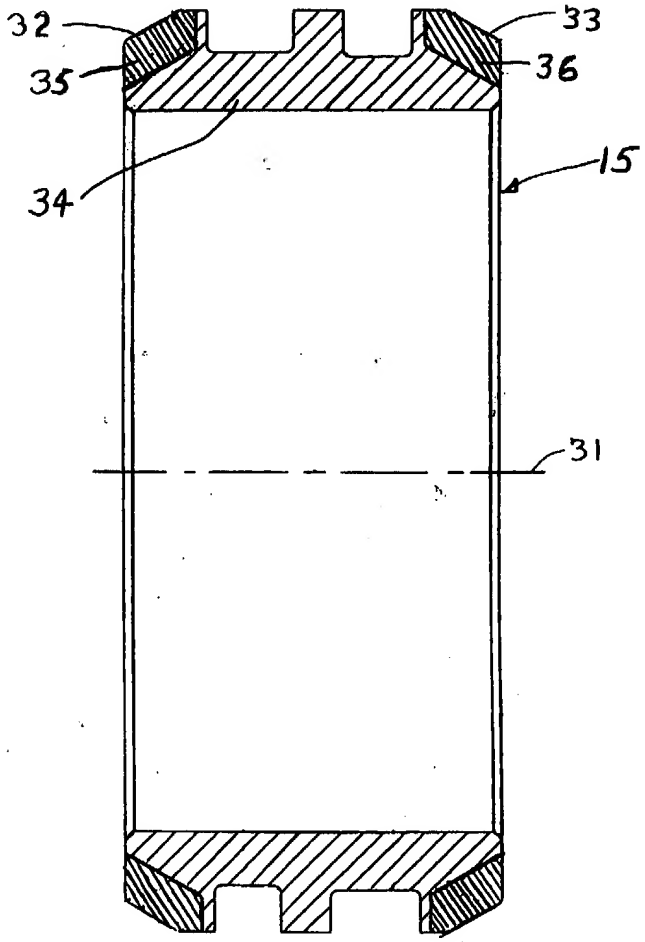


FIG. 3

In an alternative embodiment, shown in FIG. 4 reproduced below, the annular regions 35' 36' of relatively soft metal have respective annular grooves 37, 38 in the annular sealing surfaces 32', 33'. These annular grooves 37, 38 are intended to receive elastomeric O-rings to be used with the seal for sealing hub surfaces which have been slightly damaged. (Appellant's specification, page 7, lines 5 to 8; page 16 line 9 to page 17 line 7.)

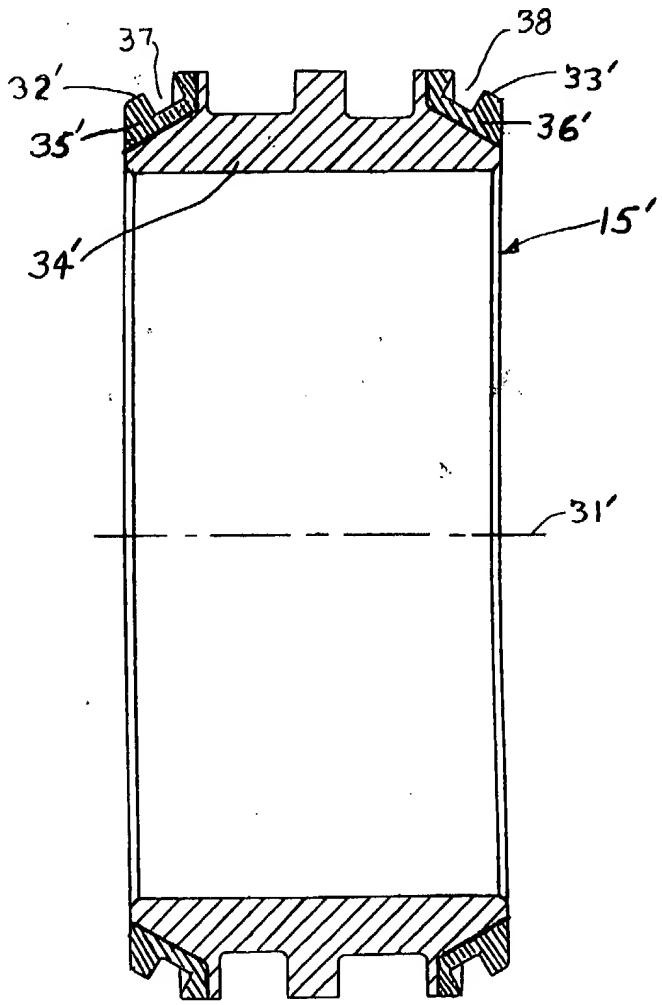


FIG. 4

In the preferred construction, the annular region of relatively soft metal 35, 36 is welded onto the relatively hard metal core 34. (Specification, page 17, lines 8 to 16; FIG. 6.)

The appellant's invention provides a number of advantages. The composite metal seal ring 15 functions as an integral piece of metal, although the properties of the metal are different in different regions of the composite metal seal ring. (Specification, page 17, lines 13 to 16.) The soft overlay metal can flow into any discontinuity that may exist in the hub seal surfaces and effect a seal. Moreover, the soft overlay metal will not scratch or impinge the hub sealing surfaces. (Specification, page 14, lines 7 to 10.) The hard metal core 34 ensures that there can be a relatively high contact stress between the metal seal ring 15 and the hub sealing surfaces. The high compressive stress in the seal enhances the seal's ability to withstand any external pressure, and internal pressure further energizes the seal. By overlaying a high strength core, the high strength capacity of the seal is maintained and a softer exterior surface is presented that will deform prior to deformation of the hub surfaces. Therefore, the hard metal core 34 ensures that the seal ring can be used after making and breaking the metal seal numerous times. (Specification, page 14, lines 11 to 21.)

VI. Issues.

1. Whether claims 1, 3, 6, 8, 10, and 13 are unpatentable under 35 U.S.C. 102(b), as being anticipated by Fyffe, U.S. Patent No. 1,426,724.

2. Whether claims 2 and 9 are unpatentable under 35 U.S.C. 103(a) over Fyffe.

3. Whether claims 4, 11, 21, and 25 are unpatentable under 35 U.S.C. 103(a) over Fyffe in view of Bloom, U.S. Patent No. 5,680,495.

4. Whether claims 5, 7, 12, and 14 are unpatentable under 35 U.S.C. 103(a) over Fyffe in

view of Poe, U.S. Patent 4,563,025.

5. Whether claim 22 is unpatentable under 35 U.S.C. 103(a) over Fyffe and Bloom and further in view of Poe.

6. Whether claims 23, 24, and 26 are unpatentable under 35 U.S.C. 103(a) over Fyffe, Bloom and Poe.

VII. Grouping of Claims.

GROUP 1. Claims 1, 3, 6, 8, 10, and 13

GROUP 2. Claims 2 and 9

GROUP 3. Claims 4, 11, 21, and 25

GROUP 4. Claims 5, 7, 12, and 14

GROUP 5. Claim 22

GROUP 6. Claims 23, 24, and 26

Appellant states that the claims in GROUP 3 do not stand or fall together, and consider that the following sub-groups A and B are each separately patentable:

Sub-Group A. Claims 4 and 11

Sub-Group B. Claims 21 and 25

Appellant states that the claims in GROUP 6 do not stand or fall together, and consider that the following sub-groups C and D are each separately patentable:

Sub-Group C. Claims 23 and 24

Sub-Group D. Claim 26

VIII. Argument.

1. Claims 1, 3, 6, 8, 10, and 13 are not unpatentable under 35 U.S.C. 102(b) and are not anticipated by Fyffe, U.S. Patent No. 1,426,724.

"For a prior art reference to anticipate in terms of 35 U.S.C. § 102, every element of the claimed invention must be identically shown in a single reference." Diversitech Corp. v. Century Steps, Inc., 7 U.S.P.Q.2d 1315, 1317 (Fed. Cir. 1988), quoted in In re Bond, 15 U.S.P.Q.2d 1566, 1567 (Fed. Cir. 1990) (vacating and remanding Board holding of anticipation; the elements must be arranged in the reference as in the claim under review, although this is not an *ipsis verbis* test).

The Final Official Action (page 2, paragraph 2) contends that in the seal in FIG. 3 of Fyffe, the annular region of relatively soft metal (c) is "integrally bonded" with the core of relatively hard metal. The appellant respectfully disagrees. There is nothing in Fyffe to suggest that the annular region of relatively soft metal (c) is "integrally bonded" with the core of relatively hard metal. To the contrary, Fyffe discloses, in column 2 lines 53-62, that the annular region of relatively soft metal is merely placed in position with respect to the core of relatively hard metal, and secured by clamping of the collars of the pipe joint:

> In use the collars are connected to the pipes or fittings to be joined, the core is then placed between the collars with soft metal seatings between the core and the collars, the coupling ring is then placed in position and screwed up so as to draw the collars towards one another and grip the soft metal seating between the core and the collars, the soft metal seating taking a bearing against the central rib.

In response to this argument, the Final Official Action (page 7, paragraph 9) said: "integrally bonded interpreted broadly can mean that the hard and soft metal of the composite

metal seal ring are held next to each other or are in contact." The appellant respectfully disagrees, because such an interpretation is an unreasonably broad interpretation. According to the Manual of Patent Examining Procedure, Section 2111:

> The broadest reasonable interpretation of the claims must also be consistent with the interpretation that those skilled in the art would reach. In re Cortright, 165 F.3d 1353, 1359, 49 USPQ2d 1464, 1468 (Fed. Cir. 1999)(The Board's construction of the claim limitation "restore hair growth" as requiring the hair to be returned to its original state was held to be an unreasonably broad interpretation of the limitation. The court held that, consistent with applicant's disclosure and the disclosure of three patents from analogous arts using the same phrase to require only some increase in hair growth, one of ordinary skill would construe "restore hair growth" to mean that the claimed method increases the amount of hair grown on the scalp, but does not necessarily produce a full head of hair.)

The specification as originally filed, page 17, lines 8 to 16, uses the term "integral bond" in the following fashion:

> A preferred method of fabricating the composite metal seal ring 15 includes a welding overlay process. This welding process deposits the relatively soft metal overlay 35, 36 onto the relatively hard metal core 34 in such a way as to produce an integral bond between them. In other words, the composite metal seal ring 15 functions as an integral piece of metal, although the properties of the metal are different in different regions of the composite metal seal ring. (Emphasis added.)

The appellant's usage of the term "integral bond" is consistent with the common meaning of the terms "integral" and 'bond" and therefore must be given legal effect. See, for example, the enclosed pages 168 and 738 from Webster's Encyclopedic Unabridged Dictionary of the English Language, Portland House, New York, New York, 1989. The applicable definition of

"bond" includes "14. adhesion between two substances or objects." The applicable definition of "integral" includes "3. made up of parts which together constitute a whole."

See also M.P.E.P. 2111.01:

> APPLICANT MAY BE OWN LEXICOGRAPHER
>
> Applicant may be his or her own lexicographer as long as the meaning assigned to the term is not repugnant to the term's well known usage. In re Hill, 161 F.2d 367, 73 USPQ 482 (CCPA 1947). Any special meaning assigned to a term "must be sufficiently clear in the specification that any departure from common usage would be so understood by a person of experience in the field of the invention." Multiform Desiccants Inc. v. Medzam Ltd., 133 F.3d 1473, 1477, 45 USPQ2d 1429, 1432 (Fed. Cir. 1998).

In short, a hard metal object and a soft metal object merely held next to each other or in contact with each other do not have adhesion between them, and the two objects do not constitute a whole. Such a pair of metal objects do not function as an integral piece of metal, as required by the appellant's specification. The definition of "integral bond" proposed in the Final Official Action is inconsistent with the usage of the term in the appellant's specification. It renders the word "integral" meaningless. It is inconsistent with the interpretation that those skilled in the art would reach. Therefore, such an interpretation is an unreasonably broad interpretation.

2. Claims 2 and 9 are not unpatentable under 35 U.S.C. 103(a) over Fyffe.

Fyffe has been distinguished above with respect to the limitations of claims 1 and 8, which are to be incorporated by reference into claims 2 and 9 in accordance with 35 U.S.C. 112, paragraph 4. In addition, the limitation of a thickness of 1/8 inch further distinguishes the combination of

Fyffe with the other references showing thin films of soft or non-corrosive material, such as gold or silver plating, at a sealing interface. A thickness of 1/8 inch or more of relatively soft material functions in a substantially different way than a thin film, for example with respect to the stress relief and plastic flow described on page 15, line 15 to page 16, line 4 of appellant's specification.

3. Claims 4, 11, 21, and 25 are not unpatentable under 35 U.S.C. 103(a) over Fyffe in view of Bloom, U.S. Patent No. 5,680,495.

The Final Official Action (page 5, paragraph 5) recognizes that Fyffe "does not disclose the first and second annular regions of soft metal to be welded onto the annular core of relatively hard metal."

Bloom discloses a hermetically sealed fiber optic device in which metal seals such as pure aluminum blocks (shown as rectangular blocks 66) are formed by injecting molten aluminum into molds, during which the molten aluminum bonds to the optical fiber chemically and forms a compression seal on the optical fibers during cooling. The metal seals are then used to define a boundary for substrate bodies used to enclose the fiber optic device, where a hermetic seal is formed between the metal seals and the substrates by compressing the substrates onto the metal seals. (See the Abstract of Bloom and FIGs. 6 and 7.) Bloom col. 6, lines 61-63 further says: "If desired, ultrasonic welding may also be performed to weld the contacting metal layers."

The Final Official Action, paragraph 5 on page 5, relies on Bloom for showing "a deformable metal seal (70), where a soft metal is welded onto a relatively hard metal (metal layer 76 and 78)." However, Bloom describes (70) as "a deformable metal layer" that "comprises a first layer 76 and a second layer 78" and that are "overlaying the [substrate] body 74." (Bloom, col. 6, lines 26-30.) In other words, the layers 76 and 78 are layers on a substrate body 74, and

two substrate bodies are bonded together to hermetically seal a fiber optic device. (See the abstract and FIG. 9.) Moreover, there is nothing in Bloom disclosing that the inner metal layer 76 is a relatively hard metal layer, and the outer metal layer 78 is a relatively soft metal layer. For example, the inner metal layer 76 consists essentially of pure aluminum, and the outer metal layer 78 consists essentially of gold. (Bloom, col. 6, lines 34-36.) One would expect pure aluminum and pure gold to have similar hardness, but essentially pure aluminum may be softer than essentially gold. See also the enclosed two pages 28-43 and 28-48 from Perry's Chemical Engineers' Handbook, Seventh Edition, McGraw-Hill, 1997, disclosing a hardness of 19 for min 99.6% pure aluminum AA designation 1060 (right-hand column of Table 28-16) and a hardness of 25 for min 99.95 % annealed gold designation UNS P00020 (right-hand column in Table 28-19). In this case, a harder metal layer (essentially gold) would be overlaid on a softer metal layer (essentially pure aluminum). Moreover, Bloom Col. 6 lines 61-63 appears to refer to the ultrasonic welding of contacting outer metal layers 70 at the complementary middle regions 72, creating a hermetic seal between the substrates 64a and 64b along the middle surface 72. (Bloom, col. 6, lines 49-58.) Furthermore, the very thin metal layers in the miniature electronic device of Bloom are not analogous to the hard and soft metal regions of the appellant's claimed invention.

The Final Official Action (paragraph 5, page 5) concludes: "It would have been obvious to one having ordinary skill in the art at the time of the invention was made to have the relatively hard metal and the relatively soft metal of Fyffe to be welded to each other, to provide a hermetic seal and gas tight seal (a seal having metal layers 76 and 78 be bonded by welding, column 6, lines 17-23, lines 31-28, lines 51-53 and 60-63)." However, it is not seen how the advantage of hermetic sealing of a miniature solid-state electronic device would provide a proper motivation

for modifying the pipe joint seal of Fyffe, nor would the proposed application of the teaching of hermetic sealing to a pipe joint result in appellant's claimed invention. It is not evident from the cited references where Fyffe is deficient in its intended purpose of making a pipe connection that is not necessarily permanent. Moreover, if one wants to hermetically seal a joint between metal pipes, in accordance with the proposed teaching of Bloom, it is not seen why one would deviate from the common practice of simply welding the pipes to each other.

The policy of the Patent and Trademark Office has been to follow in each and every case the standard of patentability enunciated by the Supreme Court in Graham v. John Deere Co., 148 U.S.P.Q. 459 (1966). M.P.E.P. § 2141. As stated by the Supreme Court:

> Under § 103, the scope and content of the prior art are to be determined; differences between the prior art and the claims at issue are to be ascertained; and the level of ordinary skill in the pertinent art resolved. Against this background, the obviousness or nonobviousness of the subject matter is determined. Such secondary considerations as commercial success, long felt but unsolved needs, failure of others, etc., might be utilized to give light to the circumstances surrounding the origin of the subject matter sought to be patented. As indicia of obviousness or nonobviousness, these inquiries may have relevancy.

148 U.S.P.Q. at 467.

The problem that the inventor is trying to solve must be considered in determining whether or not the invention would have been obvious. The invention as a whole embraces the structure, properties and problems it solves. In re Wright, 848 F.2d 1216, 1219, 6 U.S.P.Q.2d 1959, 1961 (Fed. Cir. 1988).

For the teachings of a reference to be prior art under 35 U.S.C. §103, there must be some basis for concluding that the reference would have been considered by one skilled in the particular art working on the particular problem with which the invention pertains. In re Horne, 203 U.S.P.Q. 969, 971 (C.C.P.A. 1979). Non-analogous art cannot properly be pertinent prior art under 35 U.S.C.

§103. In re Pagliaro, 210 U.S.P.Q. 888, 892 (C.C.P.A. 1981). The determination of whether a reference is from a non-analogous art is a two-step test as set forth in Union Carbide Corp. v. American Can Co., 724 F.2d 1567, 1572, 220 U.S.P.Q. 584, 588 (Fed. Cir. 1984). In Union Carbide, the court found that the first determination was whether "the reference is within the field of the inventor's endeavor." If it is not, one must proceed to the second step "to determine whether the reference is reasonably pertinent to the particular problem with which the inventor was involved." Id. "[T]he purposes of both the invention and the prior art are important in determining whether the reference is reasonably pertinent to the problem the invention attempts to solve." In re Clay, 966 F.2d 656, 659, 23 U.S.P.Q.2d 1058, 1061 (Fed. Cir. 1992).

In the present case, the appellant's invention is directed to a pressure seal for containing fluid pressure at an annular interface having a metal-to-metal contact with one or more metal annular members. Fyffe is in the appellant's field of endeavor, but Bloom is not. For example, Bloom is classified in class 385 (Optical Waveguides), and Bloom's field of search further includes class 372 (Coherent Light Generators), class 257 (Active solid-state devices, e.g., transistors, solid-state diodes), and class 437 [438? (Semiconductor device manufacturing: process)].

Bloom is not reasonably pertinent to the particular problem with which the inventor was involved. Among other things, Bloom is directed to sealing a fiber optic device by compressed metal seals; in other words, encapsulating and sealing a miniature solid-state electronic device from the surrounding environment. This is not reasonably pertinent to the appellant's problem of improving a pressure seal for containing fluid pressure at an annular interface having a metal-to-metal contact with one or more metal annular members in order to permit the metal-to-metal seal to be broken and later properly reset. There is no basis for concluding that Bloom would have

been considered by one skilled in the pipe seal art working on the particular problem with which the appellant's invention pertains.

Even if there would be some basis for concluding that a person of ordinary skill in the art would have considered Bloom, there is nothing in the prior art as a whole suggesting the desirability of modifying Fyffe in view of Bloom. Fyffe appears to be entirely satisfactory for its intended purpose of providing a pressure seal for containing fluid pressure at an annular interface having a metal-to-metal contact with one or more metal annular members in order to permit the metal-to-metal seal to be broken and later properly reset. Bloom relates to hermetically sealing a miniature solid-state electronic device from its surrounding environment. If a person of ordinary skill in the pipe seal art would be told to apply a teaching from Bloom to provide a hermetic and gas tight pipe seal by welding, it is not seen why the person of ordinary skill in the pipe seal art would deviate from the common practice of simply welding the pipes to each other.

It appears that the only motivation for modifying Fyffe to arrive at the appellant's invention is the appellant's own novel disclosure of welding a relatively soft annular metal overlay onto a relatively hard metal core. However, it is improper to attempt to establish obviousness by using the applicant's specification as a guide to combining different prior art references to achieve the results of the claimed invention. Orthopedic Equipment Co., Inc. v. United States, 702 F.2d 1005, 1012, 217 U.S.P.Q. 193, 199 (Fed. Cir. 1983). Hindsight reconstruction, using the applicant's specification itself as a guide, is improper because it fails to consider the subject matter of the invention "as a whole" and fails to consider the invention as of the date at which the invention was made. The critical inquiry is whether there is something in the prior art as a whole to suggest the desirability, and thus the obviousness, of making the combination. In re Dembiczak, 175 F.3d 994, 999-1000, 50 U.S.P.Q.2d 1614, 1617 (Fed. Cir. 1999)(actual evidence and particular findings

need to support the PTO's obviousness conclusion); Interconnect Planning Corp. v. Feil, 774 F.2d 1132, 1138, 227 U.S.P.Q. 543, 547 (Fed. Cir. 1985) ("The invention must be viewed not with the blueprint drawn by the inventor, but in the state of the art that existed at the time."); In re Fritch, 972 F.2d 1260, 1266, 23 U.S.P.Q.2d 1780, 1784 (Fed. Cir. 1992)("It is impermissible to use the claimed invention as an instruction manual or 'template' to piece together the teachings of the prior art so that the claimed invention is rendered obvious."); Fromson v. Advance Offset Plate, Inc., 755 F.2d 1549, 1556, 225 U.S.P.Q. 26, 31 (Fed. Cir. 1985) (nothing of record plainly indicated that it would have been obvious to combine previously separate lithography steps into one process). See, for example, In re Gordon et al., 733 F.2d 900, 902, 221 U.S.P.Q. 1125, 1127 (Fed. Cir. 1984) (mere fact that prior art could be modified by turning apparatus upside down does not make modification obvious unless prior art suggests desirability of modification); Ex Parte Kaiser, 194 U.S.P.Q. 47, 48 (PTO Bd. of Appeals 1975) (Examiner's failure to indicate anywhere in the record his reason for finding alteration of reference to be obvious militates against rejection).

In short, annular seals for coupling metal tubular members as in Fyffe, and welding techniques for joining metal tubular members, have been known for about 80 years since Fyffe, yet none of the art cited by the examiner applicable to annular seals suggests the appellant's invention, which admittedly offers significant advantages over the prior art. This is objective evidence of the patentability of the appellant's invention. Fromson v. Advance Offset Plate, Inc., 755 F.2d 1549, 1557, 225 U.S.P.Q. 26, 32-33 (Fed. Cir. 1985) (It is at best bizarre to assert that the subject matter claimed was merely an obvious extension of technology when none skilled in the art attempted such "extension" during the seven years when alleged economic advantages of such technology were available).

With respect to claims 21 and 25, the limitation of a thickness of 1/8 inch or more of relatively soft material further distinguishes the combination of Fyffe and Bloom with the other references showing thin films of soft or non-corrosive material, such as gold or silver plating, at a sealing interface. A thickness of 1/8 inch or more of relatively soft material functions in a substantially different way than a thin film, for example with respect to the stress relief and plastic flow described on page 15 line 15 to page 16 line 4 of appellant's specification. Claims 21 and 25 include additional limitations specifically directed to "effecting a resettable fluid pressure seal with respective annular surfaces of first and second hub members, ..." such as first and second annular regions of relatively soft metal, which are tapered in a particular way with respect to the longitudinal axis.

4. Claims 5, 7, 12, and 14 are not unpatentable under 35 U.S.C. 103(a) over Fyffe in view of Poe, U.S. Patent 4,563,025.

Claims 5, 7, 12, and 14 are dependent claims, which include by reference the limitations of at least claims 1 and 8. Fyffe has been distinguished with respect to the base claims 1 and 8, and there is nothing in Poe that makes up for the disclosure lacking in Fyffe. Moreover, each of the claims 5, 7, 12, and 14 define that an annular region of relatively soft metal has at least one annular groove in the neighborhood of the annular surface of the first annular region of relatively soft metal.

The Final Official Action (page 6, paragraph 6) says: "Poe disclose grooves on top of a deformable seal ring and the grooves are rectangular in cross-section and having walls that are perpendicular to tapered annular surfaces of the deformable seal ring (figure 5)." However, Poe says (Abstract): "The ring is designed so that the recesses separating the lands will essentially

maintain their integrity for all radial compressions to the ring which is intended for use solely within the elastic limit and below the yield point of the material of the ring." In other words, the sealing ring of Poe is directed to "the use of desirably hardened metal sealing rings made of stainless steel, for example, and cooperation with seats of softer metal or portions thereof might be deformed or scored." (Poe, col. 1, lines 34-39.) Therefore, Poe provides grooves in the sealing ring to provide multiple sealing lands, and "should a portion of the seat structure of the flange members become scored or damaged so as to prevent a complete sealing action to take effect as between such flange member and one of the sealing lands of the ring, the remaining lands will still be present to effect the sealing function. An equivalent advantage obtains where it is one of the lands that might have a marred surface; the remaining lands will effect the seal. The recesses between the sealing lands of the sealing ring are provided, additionally, in such sealing ring to distribute the stress pattern and also to enable the ring to remain within the elastic limit of the seal ring material." (Poe, Abstract.)

The Final Official Action (page 6, paragraph 6) concludes: "It would have been obvious to one having ordinary skill in the art at the time the invention was made to have the first and second annular region of relatively soft metal to have grooves as taught by Poe, to maintain the integrity of all radial compression to the ring and also to enable the ring to remain within the elastic limit of the seal ring material (abstract of Poe, lines 15-31)." However, Poe is placing grooves in relatively hard material of the seal in comparison to relatively soft material of the seat structure of the flange members. Therefore, the cited art does not provide proper motivation for putting grooves in the relatively soft metal regions of the appellant's seal. Placing grooves in the relatively soft regions of the appellant's seal would not tend to maintain the integrity of radial compression to the seal, since the grooves would tend to weaken the relatively soft regions of the

appellant's seal. The appellant, for example, puts grooves in the relatively soft material of the seal "in order to permit elastomeric O-rings to be used with the seal for sealing hub surfaces which have been slightly damaged; ..." (Appellant's specification, page 7, lines 5 to 8; page 16 line 9 to page 17 line 7.) In contrast, Poe is attempting to solve the sealing problem in a way different from the appellant's invention, by grooving relatively hard material of the seal instead of integrally bonding relatively soft material to relatively hard material of the seal.

5. Claim 22 is not unpatentable under 35 U.S.C. 103(a) over Fyffe and Bloom and further in view of Poe.

Claim 22 is dependent on claim 21, and further defines that each of the two annular regions of relatively soft metal has at least one annular groove in the neighborhood of the annular surface of the annular region of relatively soft metal, the annular groove being rectangular in cross-section and having walls that are perpendicular to the tapered annular surface of the annular region of relatively soft metal. Therefore, Fyffe and Bloom have been distinguished above with respect to claim 21 above, and Poe is distinguished for the same reasons as given above with respect to claims 5, 7, 12, and 14.

6. Claims 23, 24, and 26 are not unpatentable under 35 U.S.C. 103(a) over Fyffe, Bloom and Poe.

Claim 23 is dependent upon claim 21, and further defines that the composite metal seal ring is adapted for containing a pressure within the hubs of at least 10,000 psi. Claim 24 is also dependent on claim 21, and further defines that the composite metal seal ring has an internal diameter of at least 3 inches. Therefore, claims 23 and 24 are distinguished from Fyffe, Bloom,

and Poe for the same reasons given above with respect to claim 21.

Claim 26 is an independent claim to a composite metal seal ring for effecting a "resettable" fluid pressure seal. Claim 26 includes limitations similar to claim 21 and therefore is distinguished from Fyffe, Bloom, and Poe for the same reasons given above with respect to claim 21. In addition, claim 26 further defines that the composite metal seal ring is adapted for containing a pressure within the hubs of at least 10,000 psi, the composite metal seal ring has an internal diameter of at least 3 inches, and the composite metal seal ring is a hybrid of a pressure energized seal type AX and a compression seal type BX. In other words, the composite metal seal ring of claim 26 is especially adapted for solving the problem of making subsea pipe connections that can be set and reset a number of times during remote assembly and disassembly of high-pressure subsea pipelines. (Appellant's specification, page 2 lines 14-20; page 10 line 20 to page 11 line 1; abstract, lines 14 to 17.) It is not seen how any proper combination of Fyffe, Bloom, and Poe would solve this problem, and certainly not in the same fashion as called for by appellant's claim 26.

In view of the above, it is respectfully submitted that the final rejection of the appellant's claims should be reversed.

Respectfully submitted,

Richard C. Auchterlonie
Reg. No. 30,607
713-787-1698

HOWREY SIMON ARNOLD & WHITE, LLP
750 Bering Drive
Houston, Texas 77057-2198
713-787-1400

Date: 26 Sept. 2001

APPENDIX I.

The claims involved in this appeal are as follows:

1. A composite metal seal comprising a core of relatively hard metal, and at least one annular region of relatively soft metal that is integrally bonded with the core of relatively hard metal and that provides an annular sealing surface for effecting a fluid pressure seal.

2. The composite metal seal as claimed in claim 1, wherein the annular region of relatively soft metal has a thickness in said radial direction of at least one-eighth of an inch.

3. The composite metal seal as claimed in claim 1, wherein the core of relatively hard metal is inlaid and overlaid with the relatively soft metal of the annular region of relatively soft metal.

4. A composite metal seal comprising a core of relatively hard metal, and at least one annular region of relatively soft metal that is integrally bonded with the core of relatively hard metal and that provides an annular sealing surface for effecting a fluid pressure seal, wherein the annual region of relatively soft metal is welded onto the core of relatively hard metal.

5. The composite metal seal as claimed in claim 1, wherein the annular region of relatively soft metal has at least one annular groove in the neighborhood of the annular surface of the annular region of relatively soft metal.

6. The composite metal seal as claimed in claim 1, wherein the composite metal seal has a longitudinal axis, and the sealing surface is tapered with respect to the longitudinal axis.

7. The composite metal seal as claimed in claim 6, wherein the annular region of relatively soft metal has at least one annular groove in the neighborhood of the annular sealing surface, the annular groove being rectangular in cross-section and having walls that are perpendicular to the tapered annular sealing surface.

8. A composite metal seal ring for effecting a fluid pressure seal with respective annular surfaces of first and second hub members, the composite metal seal ring comprising an annular core of relatively hard metal, a first annular region of relatively soft metal integrally bonded to the annular core of relatively hard metal, and a second annular region of relatively soft metal integrally bonded to the annular core of relatively hard metal, the first annular region of relatively soft metal having a first annular surface for mating with the annular surface of the first hub member to effect a fluid pressure seal with the first hub member, and the second annular region of relatively soft metal having a second annular surface for mating with the annular surface of the second hub member to effect a fluid pressure seal with the second hub member, wherein the two annular regions of relatively soft metal are displaced from each other along a longitudinal axis of the composite metal seal ring.

9. The composite metal seal ring as claimed in claim 8, wherein the first annular region of relatively soft metal has a thickness in said radial direction of at least one-eighth of an

inch, and the second annular region of relatively soft metal has a thickness in said radial direction of at least one-eighth of an inch.

10. The composite metal seal ring as claimed in claim 8, wherein the annular core of relatively hard metal is inlaid and overlaid with the relatively soft metal of the first annular region of relatively soft metal, and the annular core of relatively hard metal is inlaid and overlaid with the relatively soft metal of the second annular region of relatively soft metal.

11. A composite metal seal ring for effecting a fluid pressure seal with respective annular surfaces of first and second hub members, the composite metal seal ring comprising an annular core of relatively hard metal, a first annular region of relatively soft metal integrally bonded to the annular core of relatively hard metal, and a second annular region of relatively soft metal integrally bonded to the annular core of relatively hard metal, the first annular region of relatively soft metal having a first annular surface for mating with the annular surface of the first hub member to effect a fluid pressure seal with the first hub member, and the second annular region of relatively soft metal having a second annular surface for mating with the annular surface of the second hub member to effect a fluid pressure seal with the second hub member, wherein the two annular regions of relatively soft metal are displaced from each other along a longitudinal axis of the composite metal seal ring, wherein the first annual region of relatively soft metal is welded onto the annular core of relatively hard metal, and the relatively soft metal of the second annular region of relatively soft metal is welded onto the annular core of relatively hard metal.

12. The composite metal seal ring as claimed in claim 8, wherein the first annular region of relatively soft metal has at least one annular groove in the neighborhood of the annular surface of the first annular region of relatively soft metal, and the second annular region of relatively soft metal has at least one annular groove in the neighborhood of the annular surface of the second annular region of relatively soft metal.

13. The composite metal seal ring as claimed in claim 8, wherein the composite metal seal ring has a longitudinal axis, and the annular surface of the first annular region of relatively soft metal is tapered with respect to the longitudinal axis to have a varying radius that is smallest away from the second annular region of relatively soft metal and that is largest toward the second annular region of relatively soft metal, and the annular surface of the second annular region of relatively soft metal is tapered with respect to the longitudinal axis to have a varying radius that is smallest away from the first annular region of relatively soft metal and that is largest toward the first annular region of relatively soft metal.

14. The composite metal seal ring as claimed in claim 13, wherein the first annular region of relatively soft metal has at least one annular groove in the neighborhood of the annular surface of the first annular region of relatively soft metal, the annular groove in the first annular region of relatively soft metal being rectangular in cross-section and having walls that are perpendicular to the tapered annular surface of the first annular region of relatively soft metal, and

wherein the second annular region of relatively soft metal has at least one annular groove in the neighborhood of the annular surface of the second annular region of relatively soft metal,

the annular groove in the second annular region of relatively soft metal being rectangular in cross-section and having walls that are perpendicular to the tapered annular surface of the second annular region of relatively soft metal.

21. A composite metal seal ring for effecting a resettable fluid pressure seal with respective annular surfaces of first and second hub members, the composite metal seal ring comprising an annular core of relatively hard metal, a first annular region of relatively soft metal integrally bonded to the annular core of relatively hard metal, and a second annular region of relatively soft metal integrally bonded to the annular core of relatively hard metal, the first annular region of relatively soft metal having a first annular surface for mating with the annular surface of the first hub member to effect a fluid pressure seal with the first hub member, and the second annular region of relatively soft metal having a second annular surface for mating with the annular surface of the second hub member to effect a fluid pressure seal with the second hub member, wherein the two annular regions of relatively soft metal are displaced from each other along a longitudinal axis of the composite metal seal ring;

wherein the first annular region of relatively soft metal has a thickness in said radial direction of at least one-eighth of an inch, and the second annular region of relatively soft metal has a thickness in said radial direction of at least one-eighth of an inch;

wherein the annular core of relatively hard metal is inlaid and overlaid with the relatively soft metal of the first annular region of relatively soft metal, and the annular core of relatively hard metal is inlaid and overlaid with the relatively soft metal of the second annular region of relatively soft metal;

wherein the first annual region of relatively soft metal is welded onto the annular core of relatively hard metal, and the relatively soft metal of the second annular region of relatively soft metal is welded onto the annular core of relatively hard metal;

wherein the composite metal seal ring has a longitudinal axis, and the annular surface of the first annular region of relatively soft metal is tapered with respect to the longitudinal axis to have a varying radius that is smallest away from the second annular region of relatively soft metal and that is largest toward the second annular region of relatively soft metal, and the annular surface of the second annular region of relatively soft metal is tapered with respect to the longitudinal axis to have a varying radius that is smallest away from the first annular region of relatively soft metal and that is largest toward the first annular region of relatively soft metal.

22. The composite metal seal ring as claimed in claim 21, wherein the first annular region of relatively soft metal has at least one annular groove in the neighborhood of the annular surface of the first annular region of relatively soft metal, the annular groove in the first annular region of relatively soft metal being rectangular in cross-section and having walls that are perpendicular to the tapered annular surface of the first annular region of relatively soft metal, and

wherein the second annular region of relatively soft metal has at least one annular groove in the neighborhood of the annular surface of the second annular region of relatively soft metal, the annular groove in the second annular region of relatively soft metal being rectangular in cross-section and having walls that are perpendicular to the tapered annular surface of the second annular region of relatively soft metal.

23. The composite metal seal ring as claimed in claim 21, wherein the composite metal seal ring is adapted for containing a pressure within the hubs of at least 10,000 psi.

24. The composite metal seal ring as claimed in claim 21, wherein the composite metal seal ring has an internal diameter of at least 3 inches.

25. The composite metal seal ring as claimed in claim 21, wherein the composite metal seal ring is a hybrid of a pressure energized seal type AX and a compression seal type BX.

26. A composite metal seal ring for effecting a resettable fluid pressure seal with respective annular surfaces of first and second hub members, the composite metal seal ring comprising an annular core of relatively hard metal, a first annular region of relatively soft metal integrally bonded to the annular core of relatively hard metal, and a second annular region of relatively soft metal integrally bonded to the annular core of relatively hard metal, the first annular region of relatively soft metal having a first annular surface for mating with the annular surface of the first hub member to effect a fluid pressure seal with the first hub member, and the second annular region of relatively soft metal having a second annular surface for mating with the annular surface of the second hub member to effect a fluid pressure seal with the second hub member, wherein the two annular regions of relatively soft metal are displaced from each other along a longitudinal axis of the composite metal seal ring;

wherein the first annular region of relatively soft metal has a thickness in said radial direction of at least one-eighth of an inch, and the second annular region of relatively soft metal has a thickness in said radial direction of at least one-eighth of an inch;

wherein the annular core of relatively hard metal is inlaid and overlaid with the relatively soft metal of the first annular region of relatively soft metal, and the annular core of relatively hard metal is inlaid and overlaid with the relatively soft metal of the second annular region of relatively soft metal;

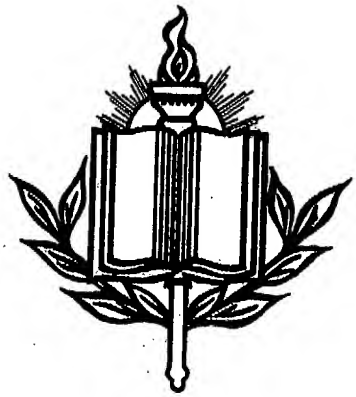
wherein the first annual region of relatively soft metal is welded onto the annular core of relatively hard metal, and the relatively soft metal of the second annular region of relatively soft metal is welded onto the annular core of relatively hard metal;

wherein the composite metal seal ring has a longitudinal axis, and the annular surface of the first annular region of relatively soft metal is tapered with respect to the longitudinal axis to have a varying radius that is smallest away from the second annular region of relatively soft metal and that is largest toward the second annular region of relatively soft metal, and the annular surface of the second annular region of relatively soft metal is tapered with respect to the longitudinal axis to have a varying radius that is smallest away from the first annular region of relatively soft metal and that is largest toward the first annular region of relatively soft metal; and

wherein the composite metal seal ring is adapted for containing a pressure within the hubs of at least 10,000 psi, the composite metal seal ring has an internal diameter of at least 3 inches, and the composite metal seal ring is a hybrid of a pressure energized seal type AX and a compression seal type BX.

page 8

Webster's Encyclopedic Unabridged Dictionary of the English Language



The dictionary entries are based on the First Edition of *The Random House Dictionary of the English Language*

PORTLAND HOUSE • NEW YORK

ACKNOWLEDGMENTS AND PERMISSIONS:

The "A Dictionary of the English Language" section of this book *(Webster's Encyclopedic Unabridged Dictionary)* is based on the first edition of *The Random House Dictionary of the English Language, the Unabridged Edition*, copyright © 1983.

Atlas of the World, copyright © 1989 by John Bartholomew & Son Limited. Reprinted by arrangement with John Bartholomew & Son Limited.

A Manual of Style, copyright © 1986 by Crown Publishers, Inc. Excerpted and reprinted by arrangement with Crown Publishers, Inc.

Krevisky, Joseph and Jordan L. Linfield—*The Bad Speller's Dictionary*, copyright © 1967, 1963 by Innovation Press. Reprinted by arrangement with Random House, Inc.

Stein, Jess, Ed.—*Rhyming Dictionary*, copyright © 1960 by Random House, Inc. Reprinted by arrangement with Random House, Inc.

Weiman, Ralph—*Living Language™ Common Usage Dictionary, French-English/English-French*, copyright 1946, 1955, © 1968, 1974, 1983, 1985 by Crown Publishers, Inc. Reprinted by arrangement with Crown Publishers, Inc.

Martin, Genevieve A. and Theodor Bertram—*Living Language™ Common Usage Dictionary, German-English/English-German*, copyright © 1956, 1985 by Crown Publishers, Inc. Reprinted by arrangement with Crown Publishers, Inc.

Martin, Genevieve A. and Mario Ciatti—*Living Language™ Common Usage Dictionary, Italian-English/English-Italian*, copyright © 1956, 1985 by Crown Publishers, Inc. Reprinted by arrangement with Crown Publishers, Inc.

Weiman, Ralph and O. A. Succar—*Living Language™ Common Usage Dictionary, Spanish-English/English-Spanish*, copyright 1946, © 1955, 1968, 1974, 1983, 1985 by Crown Publishers, Inc. Reprinted by arrangement with Crown Publishers, Inc.

Webster's Crossword Puzzle Dictionary, 1986 edition, copyright © 1963 by Fawcett Publications, Inc. and copyright © 1964 by Ottenheimer Publishers, Inc. Reprinted by arrangement with Ottenheimer Publishers, Inc.

This 1989 edition is published by Portland House, a division of dilithium Press, Ltd., distributed by Outlet Book Company, Inc., a Random House Company, 225 Park Avenue South, New York, New York 10003.

Printed and Bound in the United States of America

Library of Congress Cataloging-in-Publication Data
Webster's encyclopedic unabridged dictionary of the English language.
1. English language—Dictionaries.
PE1625.W46 1989
423—dc19 89-3785
CIP

ISBN 0-517-68781-X

10 9 8 7 6 5 4

Bön (bön), *n.* a shamanistic Tibetan sect, absorbed by the first Buddhist sects of the 7th century and later.

bo·na (bō′nə, -nä), *n.* Bône.

bo·na·ci (bō′nə sē′), *n., pl.* (*esp. collectively*) **-ci,** (*esp. referring to two or more kinds or species*) **-cis.** any of several edible serranid fishes, as *Mycteroperca bonaci.* [< Sp *bonasi* a fish]

Bo·na De·a (bō′nə dē′ə), an ancient Roman goddess of chastity and fertility, worshiped by women and believed to be the wife, sister, or daughter of Faunus. Also called **Fauna.** [< L: lit., (the) Good Goddess]

Bon-a-dox-in (bon′ə dok′sin), *n. Pharm., Trademark.* meclizine.

bo·na fide (bō′nə fīd′, bon′ə; bō′nə fī′dē), in good faith; without fraud. [< L] —**bo·na-fide** (bō′nə fīd′, bon′ə-), *adj.*

bo·na fi·des (bō′nä fī′dās; *Eng.* bō′nə fī′dēz), *Latin.* good faith; absence of fraud or deceit; the state of being exactly as claims or appearances indicate: *The bona fides of this contract is open to question.* Cf. **mala fides.**

Bon-aire (bō nâr′), *n.* an island in the E Netherlands Antilles, in the S West Indies. 5614 (1960); 95 sq. mi.

bon a·mi (bôn na mē′), *pl.* **bons a·mis** (bôn za mē′). *French.* **1.** a good friend. **2.** a lover.

bo·nan·za (bə nan′zə, bō-). *n. U.S.* **1.** a rich mass of ore, as found in mining. **2.** a source of great and sudden wealth or luck; a spectacular windfall: *The play proved to be a bonanza for its lucky backers.* [< Sp: lit., smooth sea (hence, good luck, rich vein of ore) < nasalized var. of Ml, *bonacia,* equiv. to L *bon(us)* good + *(mal)acia* calm sea < Gk *malachia* softness (*malach(ós)* soft + *-ia* -IA)]

Bo·na·parte (bō′nə pärt′; *Fr.* bô na part′), *n.* **1. Jo·rôme** (jô rōm′; *Fr.* zhô rōm′), 1784–1860, king of Westphalia 1807 (brother of Napoleon I). **2. Jo·seph** (jō′zəf; *Fr.* zhô zef′), 1768–1844, king of Naples 1806–08; king of Spain 1808–13 (brother of Napoleon I). **3. Lou·is** (lōō′ē; *Fr.* lwē; *Du.* lō′ē), 1778–1846, king of Holland 1806–10 (brother of Napoleon I). **4. Lou·is Na·po·lé·on** (lōō′ē nə pō′lē ən; *Fr.* lwē na pô lā ôN′). See **Napoleon III.** **5. Lu·cien** (lōō′shən; *Fr.* ly syaN′), 1775–1840, Prince of Canino (brother of Napoleon I). **6. Napoléon.** See **Napoleon I.** **7. Napoléon.** See **Napoleon II.** Italian, **Buonaparte.** —**Bo′na·par′te·an,** *adj.*

Bo·na·part·ist (bō′nə pär′tist), *n.* an adherent of the Bonapartes or their policies. [earlier *Buonapartist.* See BONAPARTE, -IST] —**Bo′na·part′ism,** *n.*

bon ap·pé·tit (bô na pā tē′), *French.* (I wish you) a hearty appetite.

Bon·a·ven·tu·ra (bon′ə ven chōōr′ə; *It.* bō′nä ven-tōō′rä), *n.* a boy's given name.

bon·a·ven·ture (bon′ə ven′chər, bon′ə ven′-), *n.* **1.** See **bonaventure mast.** **2.** See **bonaventure mizzen** (def. 1). [< It *buonaventura,* lit., good luck. See BONUS, VENTURE]

Bon·a·ven·ture (bon′ə ven′chər), *n.* **Saint** (*"the Seraphic Doctor"*), 1221–74, Italian scholastic theologian. Also, **Bonaventura.**

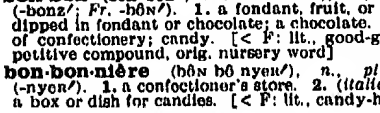
bon′aventure mast′, *Naut.* a mast fitted with a lateen sail or lugsail, situated behind the mizzenmast at or near the stern, used in the 16th and early 17th centuries. Also called **bonaventure, bonaventure mizzen.**

bon′aventure miz′zen, *Naut.* **1.** Also called **bonaventure.** a lateen sail set on a bonaventure mast. **2.** See **bonaventure mast.**

bon·a·vist (bon′ə vist), *n.* See **hyacinth bean.** [< It *buonavista* good sight. See BOON², VISTA]

bon·bon (bon′bon′; *Fr.* bôN bôN′), *n., pl.* **-bons** (-bonz′; *Fr.* -bôN′). **1.** a fondant, fruit, or nut center dipped in fondant or chocolate; a chocolate. **2.** a piece of confectionery; candy. [< F: lit., good-good; a repetitive compound, orig. nursery word]

bon·bon·nière (bôN bô nyer′), *n., pl.* **-nières** (-nyer′). **1.** a confectioner's store. **2.** (*italics*) *French.* a box or dish for candies. [< F: lit., candy-holder]



Bonds (def. 17a)
A, American bond; B, Flemish bond; C, English bond; D, English cross bond

bond[1] (bond), *n.* **1.** something that binds, fastens, confines, or holds together. **2.** a cord, rope, band, or ligament. **3.** something that binds a person or persons to a certain line of behavior: *the bond of matrimony.* **4.** something, as an agreement, friendship, etc., that unites individuals or peoples into a group; covenant: *the bond between nations.* **5.** binding security; firm assurance: *My word is my bond.* **6.** a sealed instrument under which a person, corporation, or government guarantees to pay a stated sum of money on or before a specified day. **7.** any written obligation under seal. **8.** *Law.* a written promise of a surety. **9.** *Govt.* the state of dutiable goods on which the duties are unpaid, when stored under a bond in charge of the government: *goods in bond.* **10.** Also called **bonded whiskey.** *U.S.* a whiskey that has been aged at least four years in a bonded warehouse before bottling. **11.** *Finance.* a certificate of ownership of a specified portion of a debt due to be paid by a government or corporation to an individual holder and usually bearing a fixed rate of interest. **12.** *Insurance.* a. a surety agreement. b. the money deposited, or the promissory arrangement entered into, under any such agreement. **13.** a substance that causes particles to adhere; binder. **14.** adhesion between two substances or objects, as concrete and reinforcing strands. **15.** *Chem.* the attraction between atoms in a molecule. **16.** See **bond paper.** **17.** *Masonry.* a. any of various arrangements of bricks, stones, etc., having a regular pattern and intended to increase the strength or enhance the appearance of a construction. b. the overlap of bricks, stones, etc., in a construction so as to increase its strength. **18.** *Elect.* an electric conductor placed between adjacent metal parts within a structure, as in a railroad track, aircraft, house, etc., to prevent the accumulation of static electricity. **19.** *Obs.* bondsman. —*v.t.* **20.** to put (goods, an employee, official, etc.) on or under bond: *The company refused to bond a former criminal.* **21.** to connect or bind. **22.** *Finance.* to place a bonded debt on or secure a debt by bonds; mortgage. **23.** to join (two materials). **24.** *Masonry.* to lay (bricks, stones, etc.) so as to produce a strong construction. **25.** *Elect.* to provide with a bond: *to bond a railroad track.* —*v.i.* **26.** to hold together or cohere, from or as from being bonded, as bricks in a wall or particles in a mass. [ME; var. of BAND³] —**bond′er,** *n.* —**bond′less,** *adj.*

—**Syn. 1.** bonds, chains, fetters. **3.** BOND, LINK, TIE agree in referring to a force or influence that unites people. BOND, however, usually emphasizes the strong and enduring quality of affection, whereas TIE may refer more esp. to duty, obligation, or responsibility: *bonds of memory; Blessed be the tie that binds; family ties.* A LINK is a definite connection, though a slighter one; it may indicate affection or merely some traceable influence or desultory communication: *a close link between friends.*

bond[2] (bond), *Obs.* —*n.* **1.** a serf or slave. —*adj.* **2.** in serfdom or slavery. [ME *bond(e),* OE *bōnda* < Scand; cf. Icel *bōndi* HUSBAND(MAN), contr. of **bōunde,* var. of *búande,* c. OE *būend* dweller, equiv. to *bū(an)* (to) dwell (see BOOR) + *-end* n. suffix, as in *fiend, friend*]

Bond (bond), *n.* **Car·rie** (kar′ē) (nee **Jacobs**) (jā′kobz), 1862–1946, U.S. song writer and author.

Bond, G., a ring formation in the first quadrant of the face of the moon: about 12 miles in diameter.

Bond, W., a walled plain in the first quadrant of the face of the moon: about 100 miles in diameter.

bond·age (bon′dij), *n.* **1.** slavery or involuntary servitude; serfdom. **2.** the state of being bound by or subjected to external control. **3.** *Early Eng. Law.* personal subjection to the control of a superior; villeinage. [ME < AL *bondag(ium).* See BOND², -AGE]

—**Syn. 1.** captivity, restraint; prison. See **slavery. 2.** thraldom, captivity, confinement, imprisonment.

bond′ course′, *Masonry.* a course, as a heading course, for bonding masonry in depth.

bond·ed (bon′did), *adj.* **1.** secured by or consisting of bonds: *bonded debt.* **2.** placed in bond: *bonded goods.* [BOND¹ + -ED³]

bond′ed ware′house, a warehouse for goods held in bond by the government.

bond′ed whis′key, bond[1] (def. 10).

bond·hold·er (bond′hōl′dər), *n.* a holder of a bond or bonds issued by a government or corporation. [BOND¹ + HOLDER] —**bond′hold′ing,** *adj., n.*

bond·maid (bond′mād′), *n.* **1.** a female slave. **2.** a female bound to service without wages. [BOND² + MAID]

bond·man (bond′mən), *n., pl.* **-men. 1.** a male slave. **2.** a male bound to service without wages. **3.** *Old Eng. Law.* a villein or other unfree tenant. Also, **bondsman.** [ME *bonde man.* See BOND², MAN¹]

bond′ pa′per, a superior variety of white paper, esp. used for stationery. Also called **bond.**

bond′ serv′ant, **1.** one who serves in bondage; slave. **2.** a person bound to service without wages. Also, **bond′-serv′ant.**

bonds·man[1] (bondz′mən), *n., pl.* **-men.** *Law.* one who is bound or who by bond becomes surety for another. [*bond's man* man of the bond, i.e., its signer; see BOND¹, MAN¹]

bonds·man[2] (bondz′mən), *n., pl.* **-men.** bondman. [ME *bondesman.* See BOND², MAN¹]

bond·stone (bond′stōn′), *n.* a stone, as a perpend, for bonding facing masonry to a masonry backing. [BOND¹ + STONE]

bonds·wom·an[1] (bondz′wŏŏm′ən), *n., pl.* **-wom·en.** *Law.* a woman who is bound or who by bond becomes surety for another. [*bond's woman* woman of the bond, i.e., its signer; see BONDSMAN¹]

bonds·wom·an[2] (bondz′wŏŏm′ən), *n., pl.* **-wom·en.** bondwoman. [BOND² + WOMAN]

bond·wom·an (bond′wŏŏm′ən), *n., pl.* **-wom·en.** a female slave. [ME *bonde womman.* See BOND², WOMAN]

bone[1] (bōn), *n., v.,* **boned, bon·ing.** —*n.* **1.** *Anat., Zool.* **a.** one of the structures composing the skeleton of a vertebrate. **b.** the hard, connective tissue forming the substance of the skeleton of most vertebrates. **2.** such a structure from an edible animal, usually with meat adhering to it, as an article of food: *Pea soup should be made with a ham bone.* **3.** any of various similarly hard or structural animal substances, as ivory, whalebone, etc. **4.** something made of or resembling such a substance. **5. bones, a.** the skeleton. **b.** a body: *Let his bones rest in peace.* **c.** *Games Slang.* dice. **d.** (*cap.*) See **Mr. Bones. e.** a simple rhythm instrument consisting of two, sometimes curved, bars or short strips of bone, ivory, wood, or the like, held between the fingers of one hand and clacked together. **6.** a flat strip of whalebone or other material for stiffening corsets, petticoats, etc.; stay. **7.** *Games Slang.* a domino. **8. feel in one's bones,** *U.S.* to think or feel intuitively: *She felt in her bones that it was going to be a momentous day.* **9. have a bone to pick with someone,** to have cause to disagree or argue with someone: *The teacher had a bone to pick with him because his homework paper was identical with his neighbor's.* **10. make no bones about, a.** to deal with in a direct manner; act or speak openly. **b.** to have no fear of or objection to: *He makes no bones about helping his wife with the dishes.* —*v.t.* **11.** to remove the bones from: *to bone a turkey.* **12.** to put whalebone or another stiffener into (clothing). **13.** *Agric.* to put bone meal into, as fertilizer. —*v.i.* **14.** *Slang.* to study intensely; cram (often fol. by up): *She's boning up for her finals.* [ME *boon,* OE *bān*; c. D *been* bone, leg, Icel *bein* bone, G *Bein* leg] —**bone′less,** *adj.* —**bone′like′,** *adj.*

bone[2] (bōn), *n. Jazz,* a trombone. [short form]

Bône (bōn), *n.* a seaport in NE Algeria: site of Hippo Regius. 112,010 (1954). Also, **Bona.**

bone′ ash′, the remains of bones calcined in the air, used as a fertilizer and in the making of bone china. Also called **bone′ earth′.**

bone·black (bōn′blak′), *n.* a black, carbonaceous substance obtained by calcining bones in closed vessels, used as a black pigment, a decolorizing agent, etc. Also, **bone′ black′.** [BONE¹ + BLACK]

bone′ chi′na, a fine, naturally white china made with bone ash.

bone′ conduc′tion, *Med.* the transmission of sound vibrations to the internal ear through the cranial bones (opposed to *air conduction*).

boned (bōnd), *adj.* **1.** having a particular kind of bone or bony structure (often used in combination): *heavy-boned; fully boned; raw-boned; small-boned.* **2.** having the bones taken out; cooked or served with the bones removed: *boned chicken; boned veal.* **3.** braced or supported with stays, as a corset. **4.** fertilized with bone: *boned land.* [BONE¹ + -ED³]

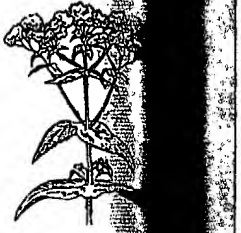
bone-dry (bōn′drī′), *adj.* **1.** *Informal.* very dry; thirsty. **2.** *Ceram.* (of clay) thoroughly dried.

bone·fish (bōn′fish′), *n., pl.* **-fish·es,** (*esp. collectively*) **-fish.** a marine game fish, *Albula vulpes,* found in shallow tropical waters, having a skeleton composed of numerous small, fine bones. Also called **ladyfish.** [BONE¹ + FISH]

bone·head (bōn′hed′), *n.* a stupid, obstinate person; blockhead. [BONE¹ + HEAD] —**bone′head′ed,** *adj.* —**bone′head′ed·ness,** *n.*

bone′ meal′, *Agric.* bones ground to a coarse powder, used as fertilizer or feed.

bone′ of conten′tion, the subject or focal point of a dispute: *The terms of the old man's will were a bone of contention to his survivors.*



Boneset (*Eupatorium perfoliatum*) (Height 3 to 6 ft.)

bone′ oil′, a fetid, tarry liquid obtained in the dry distillation of bone.

bon·er[1] (bō′nər), *n.* one who or that which bones. [BONE¹ + -ER¹]

bon·er[2] (bō′nər), *n. Slang.* a foolish and obvious blunder. [BONE(HEAD) + -ER¹]

bone·set (bōn′set′), *n.* any plant of the genus *Eupatorium,* esp. *E. perfoliatum,* of North America. Also called **thoroughwort.** [BONE¹ + SET (V.), so named (by hyperbole) because supposed to have healing properties]

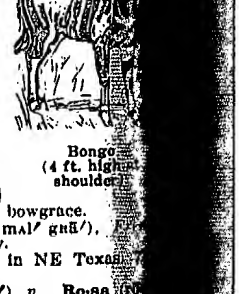
bone·set·ter (bōn′set′ər), *n.* one who treats or sets fractures, broken, or dislocated bones, or the like, esp. such a person who is not a regular physician or surgeon; healer. [late ME; see BONE¹, SETTER]

bone′ spav′in, *Vet. Pathol.* See under **spavin** (def. 1).

bone′ tur′quoise, fossil bone or ivory that has been colored naturally or artificially so as to resemble turquoise. Also called **fossil turquoise, odontolite.**

bone·yard (bōn′yärd′), *n.* **1.** Also called *Dominoes.* the bank, consisting of the remaining dominoes after each person has made his initial draw. **2.** a place or area where the bones of wild animals accumulate or are collected. **3.** *Informal.* an area where old, useless, or discarded cars, ships, planes, etc., are collected prior to being broken up for scrap or otherwise disposed of. [BONE¹ + YARD²]

bon·fire (bon′fīr′), *n.* **1.** a large fire in the open air, for warmth, entertainment, or celebration, to burn leaves, garbage, etc., or as a signal. **2.** any fire built in the open. [late ME *bone fire,* i.e., a fire with bones for fuel]



Bongo (4 ft. high at shoulder)

bon·go[1] (bong′gō, bông′gō′-), *n., pl.* **-gos** (*esp. collectively*) **-go.** a reddish-brown antelope, *Taurotragus euryceros,* of the forests of tropical Africa, having white stripes and large, spirally twisted horns. [< an African language]

bon·go[2] (bong′gō, bông′gō′-), *n., pl.* **-gos, -goes.** one of a pair of small tuned drums, played by beating with the fingers. Also called **bon′go drum′.** [< Amer Sp *bongó*]

bon·grace (bon′grās′), *n. Naut.* bowgrace.

bon gré, mal gré (bôN′ grā′ mal′ grā′), whether willing or not; willy-nilly.

Bon·ham (bon′əm), *n.* a town in NE Texas. 7,163 (1960).

Bon·heur (bô nœr′; *Fr.* bô nœr′), *n.* **Ro·sa** (rō′zə; *Fr.* rōz a′), (*Maria Rosalie Bonheur*), 1822–99, French painter.

bon·heur-du-jour (bô nœr′dōō zhōōr′, -dyōō-; bō nœr dy zhōōr′), *n., pl.* **bon·heurs-du-jour** (bô nœr′dōō zhōōr′, -dyōō-; *Fr.* bō nœr dy zhōōr′). *French Furniture.* a dainty fall-front desk of the 18th and early 19th centuries. [< F: lit., happiness of the day, from the favor it found in its time]

bon·ho·mie (bon′ə mē′; *Fr.* bô nô mē′), *n.* frank, simple good-heartedness; a good-natured manner. [< F, equiv. to *bonhomme* good-natured man (see BONHOMME) + *-ie* -Y³] —**bon·ho·mous** (bon′ə məs), *adj.*

Bon·homme Rich·ard (bon′əm rich′ərd; *Fr.* nôm′ rē shar′), the flagship of John Paul Jones.

Bon·i·face (bon′ə fās′; *for 4 also Fr.* bô nē fas′), **1. Saint** (*Wynfrith*), A.D. 680?–755?, English monk who became a missionary in Germany. **2.** a jovial innkeeper in *The Beaux' Stratagem.* **3.** (*l.c.*) any landlord or innkeeper. **4.** a boy's given name.

Boniface I, Saint, died A.D. 422, pope 418–422.

Boniface II, pope A.D. 530–532.

Boniface III, pope A.D. 607.

Boniface IV, Saint, pope A.D. 608–615.

Boniface V, died A.D. 625, pope 619–625.

Boniface VI, pope A.D. 896.

Boniface VII, antipope A.D. 974, 984–985.

Boniface VIII, (*Benedetto Caetani*) c1235–1303, Italian ecclesiastic: pope 1294–1303.

Boniface IX, (*Pietro Tomacelli*) died 1404, Italian ecclesiastic: pope 1389–1404.

Bon·ing·ton (bon′iŋ tən), *n.* **Richard** (rich′ərd), 1801–28, English painter.

Bo′nin Is′lands (bō′nin), a group of islands in the N Pacific, SE of Japan: under U.S. administration; uninhabited since World War II. 40 sq. mi. Japanese, **Ogasawara Jima.**

Bo·ni·ta (bō nē′tə, bō-), *n.* a girl's given name.

bo·ni·to (bō nē′tō), *n., pl.* (*esp. collectively*) **-to,** (*esp. referring to two or more kinds or species*) **-tos.** any mackerellike fish of the genus *Sarda,* as *S. sarda,*

sult implies such insolence of speech or manner as deeply humiliates or wounds one's feelings and arouses to anger. Indignity is especially used of inconsiderate, contemptuous treatment toward one entitled to respect. Affront implies open disrespect or offense shown, as it were, to the face. Slight may imply inadvertent indifference or disregard, which may also indicate ill-concealed contempt. —**Ant.** 1, 4. compliment.

in·sul·ta·tion (in′səl tā′shən), *n.* *Archaic.* insult. [< L *insultātiōn-* (s. of *insultātiō*), equiv. to *insultāt(us)* insulted (ptp. of *insultāre*) + *-iōn-* -ION]

in·sult·ing (in sul′ting), *adj.* tending to give or cause insult; characterized by rudeness, insolence, etc. [INSULT + -ING²] —**in·sult′ing·ly**, *adv.*

in·su·per·a·ble (in sōō′pər ə bəl), *adj.* incapable of being passed over, overcome, or surmounted: *an insuperable barrier.* [ME < L *insuperābil(is)*. See IN-³, SUPERABLE] —**in·su′per·a·bil′i·ty, in·su′per·a·ble·ness**, *n.* —**in·su′per·a·bly**, *adv.*

in·sup·port·a·ble (in′sə pôr′tə bəl, -pōr′-), *adj.* 1. not endurable; insufferable. 2. incapable of support, as by evidence or collected facts: *an insupportable accusation.* [< LL *insupportābil(is)*. See IN-³, SUPPORTABLE] —**in′sup·port′a·ble·ness**, *n.* —**in′sup·port′a·bly**, *adv.*

in·sup·press·i·ble (in′sə pres′ə bəl), *adj.* incapable of being suppressed: *his insuppressible humor.* [IN-³ + SUPPRESSIBLE] —**in′sup·press′i·bly**, *adv.*

in·sur·a·ble (in shŏŏr′ə bəl), *adj.* capable of being insured, as against risk of loss or harm; proper to be insured. [INSURE + -ABLE] —**in·sur′a·bil′i·ty**, *n.*

in·sur·ance (in shŏŏr′əns), *n.* 1. the act, system, or business of insuring property, life, one's person, etc., against loss or harm arising in specified contingencies, as fire, accident, death, disablement, or the like, in consideration of a payment proportionate to the risk involved. 2. coverage by contract in which one party agrees to indemnify or reimburse another for any loss that occurs under the terms of the contract. 3. the contract itself, set forth in a written or printed agreement or policy. 4. the amount for which anything is insured. 5. *Rare.* an insurance premium. [INSURE + -ANCE]

in·sur·ant (in shŏŏr′ənt), *n.* *Rare.* a person who takes out an insurance policy. [INSURE + -ANT]

in·sure (in shŏŏr′), *v.*, **-sured, -sur·ing.** —*v.t.* 1. to guarantee against loss or harm. 2. to secure indemnity to or on, in case of loss, damage, or death. 3. to issue or procure an insurance policy on or for. 4. ensure (defs. 1–3). —*v.i.* 5. to issue or procure an insurance policy. [var. of ENSURE] —**Syn.** 1. warrant. 4. assure.

in·sured (in shŏŏrd′), *n.* a person covered by an insurance policy. [INSURE + -ED²]

in·sur·er (in shŏŏr′ər), *n.* 1. *Insurance.* a person or company that contracts to indemnify another in the event of loss or damage. 2. one who or that which insures. [INSURE + -ER¹]

in·sur·gence (in sûr′jəns), *n.* an act of rebellion. [INSURG(ENT) + -ENCE]

in·sur·gen·cy (in sûr′jən sē), *n.* state or condition of being insurgent; insurrection against an existing government by a group not recognized as having the status of a belligerent; rebellion without a revolutionary government. [INSURGEN(T) + -CY]

in·sur·gent (in sûr′jənt), *n.* 1. a person who rises in forcible opposition to lawful authority, esp. one who engages in armed resistance to a government or to the execution of its laws; rebel. 2. *U.S. Politics.* a member of a section of a political party that revolts against the methods or policies of the party. —*adj.* 3. rising in revolt; rebellious. 4. surging or rushing in: *The insurgent waves battered the shore.* [< L *insurgent-* (s. of *insurgēns*) rising up against, prp. of *insurgere*. See IN-³, SURGE, -ENT]

insur′ing clause′, the clause in an insurance policy setting forth the kind and degree of coverage granted by the insurer.

in·sur·mount·a·ble (in′sər moun′tə bəl), *adj.* incapable of being surmounted, passed over, or overcome: *an insurmountable obstacle.* [IN-³ + SURMOUNTABLE] —**in′sur·mount′a·bil′i·ty, in′sur·mount′a·ble·ness**, *n.* —**in′sur·mount′a·bly**, *adv.*

in·sur·rec·tion (in′sə rek′shən), *n.* 1. the act or an instance of rising in arms or open rebellion against civil authority or an established government. 2. any act or instance of revolt or open resistance to established authority. [late ME < LL *insurrectiōn-* (s. of *insurrectiō*), equiv. to *insurrect(us)* risen up against (ptp. of *insurgere*) + *-iōn-* -ION] —**in′sur·rec′tion·al**, *adj.* —**in′sur·rec′tion·al·ly**, *adv.* —**in′sur·rec′tion·ism**, *n.* —**in′sur·rec′tion·ist**, *n.* —**Syn.** 1. insurgency, uprising. 2. mutiny. See revolt.

in·sur·rec·tion·ar·y (in′sə rek′shə ner′ē), *adj.*, *n.*, *pl.* **-ar·ies.** —*adj.* 1. of, pertaining to, or of the nature of insurrection. 2. given to or causing insurrection. —*n.* 3. a person who engages in insurrection; rebel; insurgent. [INSURRECTION + -ARY]

in·sur·rec·tion·ise (in′sə rek′shə nīz′), *v.t.*, **-ised, -is·ing.** *Chiefly Brit.* insurrectionize.

in·sur·rec·tion·ize (in′sə rek′shə nīz′), *v.t.*, **-ized, -iz·ing.** 1. to cause insurrection in (a country or the like). 2. to rouse (a person, group, or people) to insurgent action. [INSURRECTION + -IZE]

in·sus·cep·ti·ble (in′sə sep′tə bəl), *adj.* not susceptible; incapable of being influenced or affected (usually fol. by *of* or *to*): *insusceptible of flattery; insusceptible to infection.* [IN-³ + SUSCEPTIBLE] —**in′sus·cep′ti·bil′i·ty, n.** —**in′sus·cep′ti·bly**, *adv.*

in·swathe (in swāth′), *v.t.*, **-swathed, -swath·ing.** *Rare.* enswathe. —**in·swathe′ment**, *n.*

in·swept (in′swept′), *adj.* tapering at the front or tip, as an airplane wing. [adj. use of v. phrase *swept in*]

in·swing·er (in′swing′ər), *n.* *Cricket.* a bowled ball that veers from off side to leg side. Cf. outswinger. [IN + SWINGER]

int., 1. interest. 2. interim. 3. interior. 4. interjection. 5. internal. 6. international. 7. interpreter. 8. interval. 9. intransitive.

in·tact (in takt′), *adj.* 1. not altered, broken or impaired; remaining uninjured, sound, or whole: *The vase remained intact despite rough handling in shipment.* 2. not changed or diminished; not influenced or swayed: *Despite his misfortunes, his faith and optimism are still intact.* 3. complete or whole, esp. not castrated or emasculated. 4. having the hymen unbroken; virginal. [late ME < L *intact(us)* untouched, equiv. to *in-* IN-³ + *tactus*, ptp. of *tangere* to touch] —**in·tact′ly**, *adv.* —**in·tact′ness**, *n.*

—Syn. 1. See complete.

in·tag·lio (in tal′yō, -täl′-; *It.* ēn täl′yô), *n.*, *pl.* **-tag·li·os**, *It.* **-ta·gli** (-tä′lyē). 1. a gem, seal, piece of jewelry, or the like, cut with an incised or sunken design. 2. incised carving, as opposed to carving in relief. 3. ornamentation with a figure or design sunk below the surface. 4. an incised or countersunk die. 5. a figure or design so produced. 6. a process in which a design, text, etc., is engraved into the surface of a plate so that when ink is applied and the excess is wiped off, ink remains in the grooves and is transferred to paper in printing, as in engraving, drypoint, etching, etc. 7. an impression or printing from such a design, engraving, etc. [< It, deriv. of *intagliare* to cut in, engrave, equiv. to *in-* IN-² + *tagliare* to cut < LL *tāliāre*, deriv. of L *tālea* a cutting; see TALLY]

in·take (in′tāk′), *n.* 1. the point at which a fluid is taken into a channel, pipe, etc. 2. the act or an instance of taking in. 3. that which is taken in. 4. a quantity taken in: *the intake of oxygen.* 5. a narrowing; contraction. [n. use of v. phrase *take in*]

in·tan·gi·ble (in tan′jə bəl), *adj.* 1. not tangible; incapable of being perceived by the sense of touch, as incorporeal or immaterial things. 2. not definite or clear to the mind: *intangible arguments.* 3. (of an asset) existing only in connection with something else, as the good will of a business. —*n.* 4. something intangible, esp. an intangible asset. [< ML *intangibil(is)*. See IN-³, TANGIBLE] —**in·tan′gi·bil′i·ty, in·tan′gi·ble·ness**, *n.* —**in·tan′gi·bly**, *adv.*

in·tar·si·a (in tär′sē ə), *n.* an art or technique of decorating a surface with inlaid patterns, esp. of wood mosaic, developed during the Renaissance. Also, **tarsia.** [IN-² + It *tarsia* < Ar *tarsī* an inlay] —**in·tar·si·ate** (in tär′sē āt′, -it), *adj.*

in·tar·sist (in tär′sist), *n.* a person who creates in or practices intarsia. [INTARS(IA) + -IST]

in·te·ger (in′ti jər), *n.* 1. one of the positive or negative numbers 1, 2, 3, 4, etc., or 0; a whole number, as distinguished from a fraction or a mixed number. 2. a complete entity. [< L: untouched, hence, undivided, whole, equiv. to *in-* IN-³ + *-teg-* (var. of *tag-*, ptp. s. of *tangere* to touch) + *-er* adj. suffix]

in·te·ger vi·tae (in′tə gər wē′tī; *Eng.* in′ti jər vī′tē), *Latin.* blameless in life; innocent. Horace, *Odes*, I.

in·te·gra·ble (in′tə grə bəl), *adj.* *Math.* capable of being integrated, as a mathematical function or differential equation. [INTEGR(ATE) + -ABLE] —**in′te·gra·bil′i·ty**, *n.*

in·te·gral (in′tə grəl), *adj.* 1. of, pertaining to, or belonging as a part of the whole; constituent or component: *the integral parts of the human body.* 2. necessary to the completeness of the whole: *This point is integral to his plan.* 3. made up of parts which together constitute a whole. 4. entire; complete; whole: *the integral works of a writer.* 5. *Arith.* pertaining to or being an integer; not fractional. 6. *Math.* pertaining to or involving integrals. —*n.* 7. an integral whole. 8. *Math.* a. Also called **Riemann integral**, the numerical measure of the area bounded above by the graph of a given function, below by the *x-axis*, and on the sides by ordinates drawn at the endpoints of a specified interval; the limit, as the norm of partitions of the given interval approaches zero, of the sum of the products of the function evaluated at a point in each subinterval times the length of the subinterval. b. a primitive. c. any of several analogous quantities. Cf. **improper integral, line integral, multiple integral, surface integral.** [< LL *integrāl(is)*. See INTEGER, -AL¹] —**in·te·gral·i·ty** (in′tə gral′ə tē), *n.* —**in′te·gral·ly**, *adv.*

in′te·gral cal′culus, the branch of mathematics that deals with integrals, esp. the methods of ascertaining indefinite integrals and applying them to the solution of differential equations and the determining of areas, volumes, and lengths.

in′te·gral curve′, *Math.* a curve that is a geometric representation of a functional solution to a given differential equation.

in′te·gral domain′, *Math.* a commutative ring in which the cancellation law holds true. Also called **domain of integrity.**

in′te·gral equa′tion, *Math.* an equation in which an integral involving a dependent variable appears.

in′te·gral test′, *Math.* the theorem that a given infinite series converges if the function whose value at each integer is the corresponding term in the series is decreasing, tends to zero, and results in a finite number when integrated from one to infinity.

in·te·grand (in′tə grand′), *n.* *Math.* the expression to be integrated. [< L *integrand(um)*, n. use of neut. of *integrandus*, ger. of *integrāre* to INTEGRATE]

in·te·grant (in′tə grənt), *adj.* 1. making up or being a part of a whole; constituent. —*n.* 2. an integrant part. 3. a solid, rigid sheet of building material composed of several layers of the same or of different materials. [< L *integrant-* (s. of *integrāns*) making whole, prp. of *integrāre*. See INTEGER, -ANT]

in·te·graph (in′tə graf′, -gräf′), *n.* integrator (def. 2). [b. INTEGRATE and -GRAPH]

in·te·grate (in′tə grāt′), *v.*, **-grat·ed, -grat·ing.** —*v.t.* 1. to bring together or incorporate (parts) into a whole. 2. to make up, combine, or complete to produce a whole or a larger unit, as parts do. 3. to unite or combine. 4. to indicate the total amount or the mean value of. 5. *Math.* to find the integral of. 6. *U.S.* a. to combine (educational facilities, classes, and the like, previously segregated by race) into one unified system. b. to give or cause to give equal opportunity to members of all races, religions, and ethnic groups, esp. to Negroes, to belong to, be employed by, be customers of, or vote in (an organization, place of business, city, State, etc.): *to integrate a restaurant; to integrate a country club.* c. to give or cause to give equal opportunity and consideration to (a racial, religious, or ethnic group or a member of such a group): *to integrate the Negroes in Mississippi.* —*v.i.* *U.S.* 6. (of a school, neighborhood, place of business, city, etc.) to become integrated. 7. (of a racial, religious, or ethnic group) a. to become integrated. b. to meld with and become part of the dominant culture. [< L *integrāt(us)* made whole, restored (ptp. of *integrāre*). See INTEGER, -ATE¹] —**in′te·gra′tive**, *adj.*

in·te·grat·ed (in′tə grā′tid), *adj.* 1. having on a basis of equal membership individuals of different racial, religious, and ethnic groups: *an integrated school.* 2. not segregated. 2. combining or coordinating separate elements so as to provide a harmonious, interrelated whole: *an integrated plot; an integrated course of study.* 3. organized or structured so that constituent units function cooperatively: *an integrated economy.* 4. *Sociol.* of or pertaining to a group or society whose members interact on the basis of commonly held norms or values. 5. *Psychol.* characterized by integration. [INTEGRATE + -ED²]

in′tegrated bar′, *Law.* (in some States) a system of bar associations to which all lawyers are required to belong. Also called **incorporated bar.**

in′tegrated da′ta proc′essing, the processing of information by systematic techniques which reduce human intervention to a minimum and which employ a language common to all the machines in the system. *Abbr.:* IDP Cf. **automatic data processing.**

in′tegrating fac′tor, *Math.* a factor that upon multiplying a differential equation with right-hand side equal to zero makes the equation integrable, usually by making the resulting expression an exact differential of some function.

in·te·gra·tion (in′tə grā′shən), *n.* 1. the act or an instance of combining into an integral whole. 2. behavior, as of an individual, that is in harmony with its environment. 3. *Psychol.* the organization of the constituent elements of the personality into a coordinated, harmonious whole. 4. *Math.* the operation of finding the integral of a function or equation, esp. solving a differential equation. 5. *U.S.* a. the combination of educational and other public facilities, previously segregated by race, into one unified system. b. the act or an instance of integrating an organization, place of business, city, etc. c. the act or an instance of integrating a racial, religious, or ethnic group. [INTEGRATE + -ION; cf. L *integrātiō* renewal]

integra′tion by parts′, a method of evaluating an integral by use of the formula, $\int uv = uv - \int vdu$.

in·te·gra·tion·ist (in′tə grā′shə nist), *n.* *U.S.* a person who works for or favors the integration of educational and other public facilities. [INTEGRATION + -IST]

in·te·gra·tor (in′tə grā′tər), *n.* 1. one who or that which integrates. 2. an instrument for performing numerical integrations. [INTEGRATE + -OR²]

in·teg·ri·ty (in teg′rə tē), *n.* 1. soundness of and adherence to moral principle and character; uprightness; honesty. 2. the state of being whole, entire, or undiminished: *to preserve the integrity of the empire.* 3. sound, unimpaired, or perfect condition: *the integrity of the text; the integrity of a ship's hull.* [late ME *integrite* < L *integritās*. See INTEGER, -ITY] —**Syn.** 1. rectitude, probity, virtue. See honor. —**Ant.** 1. dishonesty.

in·teg·u·ment (in teg′yə mənt), *n.* 1. a natural covering, as a skin, shell, rind, etc. 2. any covering, coating, enclosure, etc. [< L *integument(um)* a covering, IN-², TEGUMENT] —**Syn.** 1, 2. cortex. 2. involucre, involucrum, wrapper, cloak.

in·teg·u·men·ta·ry (in teg′yə men′tə rē), *adj.* pertaining to, or like an integument. [INTEGUMENT + -ARY]

in·tel·lect (in′tᵊlekt′), *n.* 1. the power or faculty of the mind by which one knows or understands, as distinguished from that by which one feels and that by which one wills; the understanding; the faculty of thinking and acquiring knowledge. 2. capacity for thinking and acquiring knowledge, esp. of a high order; mental capacity. 3. a particular mind or intelligence, esp. of high order. 4. a person possessing a great capacity of thought and knowledge. 5. minds collectively, as a number of persons, or the persons themselves. [ME < L *intellect(us)*, equiv. to *intellect-* (ptp. s. of *intelligere* understand; see INTELLIGENT) + *-us* n. suffix] —**Syn.** 1. reason, sense, common sense, brains, mind. —**Ant.** 1. inanity.

in·tel·lec·tion (in′tᵊlek′shən), *n.* 1. the action or process of understanding; the exercise of the intellect. 2. a particular act of the intellect. 3. a conception or idea as the result of such an act. [late ME < ML *intellectiōn-* (s. of *intellectiō*). See INTELLECT, -ION]

in·tel·lec·tive (in′tᵊlek′tiv), *adj.* 1. having power to understand; intelligent. 2. of or pertaining to the intellect. [late ME < L *intellectīv(us)*. See INTELLECT, -IVE] —**in′tel·lec′tive·ly**, *adv.*

in·tel·lec·tu·al (in′tᵊlek′chōō əl), *adj.* 1. appealing to or engaging the intellect: *intellectual pursuits.* 2. of or pertaining to the intellect or its use: *intellectual power.* 3. directed or inclined toward things that involve the intellect: *intellectual tastes.* 4. possessing or showing intellect or mental capacity, esp. to a high degree: *intellectual person.* 5. guided or developed by or relying on the intellect rather than upon emotions or feelings. 6. characterized by or suggesting a predominance of intellect: *an intellectual way of speaking.* —*n.* 7. a person of superior intellect. 8. a person who places a high value on or pursues things of interest to the intellect, esp. more complex forms and fields of knowledge, as scientific or philosophical matters, esp. on an abstract and theoretical level. 9. an extremely rational person; one who relies on intellect rather than on emotions or feelings. 10. a person professionally engaged in mental labor, as a writer, teacher, etc., as distinguished from a manual laborer or businessman. 11. **intellectuals,** *Obs.* things pertaining to the intellect. [ME < L *intellectuāl(is)*, equiv. to *intellectu(s)* INTELLECT + *-ālis* -AL¹] —**in′tel·lec′tu·al·ly**, *adv.* —**in′tel·lec′tu·al·ness**, *n.* —**Syn.** 1, 2. mental. 4. See intelligent. —**Ant.** 1. animal, sensual.

in·tel·lec·tu·al·ise (in′tᵊlek′chōō ə līz′), *v.t.*, **-ised, -is·ing.** *Chiefly Brit.* intellectualize. —**in′tel·lec′tu·al·i·sa′tion**, *n.* —**in′tel·lec′tu·al·is′er**, *n.*

in·tel·lec·tu·al·ism (in′tᵊlek′chōō ə liz′əm), the exercise of the intellect. 2. devotion to intellectual pursuits. 3. excessive emphasis on abstract or intellectual matters, esp. with a lack of proper consideration of emotions. 4. *Philos.* a. the doctrine that knowledge is wholly or chiefly derived from pure reason. b. the belief that reason is the final principle of reality. [INTELLECTUAL + -ISM] —**in′tel·lec′tu·al·ist**, *n.*

CONCISE ETYMOLOGY KEY: <, descended or derived from; >, whence; b., blend of, blended; c., cognate with; deriv., derivative; equiv., equivalent; imit., imitative; m., modification of; obl., oblique; r., replacing; s., stem; sp., spelling; trans., translation; ?, origin unknown, perhaps; *, hypothetical. See the full key inside the front cover.

PERRY'S CHEMICAL ENGINEERS' HANDBOOK

SEVENTH EDITION

McGraw-Hill
New York
San Francisco
Washington, D.C.
Auckland
Bogotá
Caracas
Lisbon
London
Madrid
Mexico City
Milan
Montreal
New Delhi
San Juan
Singapore
Sydney
Tokyo
Toronto

Prepared by a staff of specialists under the editorial direction of

Late Editor
Robert H. Perry

Editor
Don W. Green
Deane E. Ackers Professor of Chemical and Petroleum Engineering, University of Kansas

Associate Editor
James O. Maloney
Professor Emeritus of Chemical Engineering, University of Kansas

Library of Congress Cataloging-in-Publication Data

Perry's chemical engineers' handbook. — 7th ed. / prepared by a staff of specialists under the editorial direction of late editor Robert H. Perry : editor, Don W. Green : associate editor, James O'Hara Maloney.
p. cm.
Includes index.
ISBN 0-07-049841-5 (alk. paper)
1. Chemical engineering—Handbooks, manuals, etc. I. Perry, Robert H., date. II. Green, Don W. III. Maloney, James O.
TP151.P45 1997
660—dc21 96-51648
CIP

McGraw-Hill
A Division of The McGraw-Hill Companies

4 5 6 7 8 9 0 DOW/DOW 9 0 2 1 0 9

ISBN 0-07-049841-5

INTERNATIONAL EDITION

When ordering this title, use ISBN 0-07-115448-5.

The sponsoring editors for this book were Zoe Foundotos and Robert Esposito, the editing supervisor was Marc Campbell, and the production supervisor was Pamela A. Pelton. It was set in Caledonia by North Market Street Graphics.

Printed and bound by R. R. Donnelley & Sons Company.

This book was printed on acid-free paper.

ABLE 28-16 Aluminum Alloys

AA signation	UNS	Composition, %*						Condition†	Mechanical properties†			
		Cr	Cu	Mg	Mn	Si	Other		Yield strength, kip/in² (MPa)	Tensile strength, kip/in² (MPa)	Elongation in 2 in, %	Hardness‡ HB
ought												
1060	A91060						99.6 Al min.	0	4 (28)	10 (69)	43	19
1100	A91100		0.05–0.2				99.0 Al min.	0	5 (34)	13 (90)	45	23
2024	A92024	0.1	3.8–4.9	1.2–1.8	0.3–0.9	0.5		T4	47 (324)	68 (469)	19	120
3003	A93003		0.05–0.2		1.0–1.5	0.6		H14	21 (145)	22 (152)	16	40
5052	A95052	0.15–0.35	0.1	2.2–2.8	0.1			0	13 (90)	2.8 (193)	30	47
5083	A95083	0.05–0.25	0.1	4.0–4.9	0.4–1.0	0.4		0	21 (145)			
5086	A95086	0.05–0.25	0.1	3.5–4.5	0.2–0.7	0.4		0	17 (117)	38 (262)	30	
5154	A95154	0.05–0.35	0.1	3.1–3.9	0.1	0.25		0	17 (117)	35 (241)	27	58
6061	A96061	0.04–0.35	0.15–0.4	0.8–1.2	0.15	0.4–0.8		T6	40 (276)	45 (310)	17	95
6063	A96063	0.1	0.1	0.45–0.9	0.1	0.2–0.6		T6	31 (214)	35 (241)	18	73
7075	A97075	0.18–0.28	1.2–2.0	2.1–2.9	0.3	0.40	5.1–6.1 Zn	T6	73 (503)	63 (572)	11	150
2ng												
242.0	A02420	0.25	3.5–4.5	1.2–1.8	0.35	0.7	1.7–2.3 Ni	S-T571		29 (200)		
295.0	A02950		4.0–5.0	0.03	0.35	0.7–1.5		S-T4		29 (200)	6	
332.0	A13320		0.5–1.5	0.7–1.3	0.35	11–13	2.0–3.0 Ni	P-T551		31 (214)		
443.0	A24430		0.15	0.05	0.35	4.5–6.0		S-F		17 (117)	3	
514.0	A05140		0.15	3.5–4.5	0.35	0.35		S-F		22 (152)	6	
520.0	A05200		0.25	9.5–10.6	0.15	0.25		S-T4	22 (152)	42 (290)	12	

*Single values are maximum values.
†Typical room-temperature properties.
‡S = sand-cast; P = permanent-mold-cast; other = temper designations.
SOURCE: Aluminum Association. Courtesy of National Association of Corrosion Engineers. To convert MPa to lbf/in², multiply by 145.04.

plastic. This membrane functions as a barrier to protect the substrate from corrosion damage. A special prestressed-brick design that maintains the brick in compression by using a controlled-expansion mous mortar and brick bedding material precludes the use of an stomeric membrane.

Cement and Concrete Concrete is an aggregate of inert reinforcing particles in an amorphous matrix of hardened cement paste. ncrete made of portland cement has limited resistance to acids and es and will fail mechanically following absorption of crystal-ming solutions such as brines and various organics. Concretes de of corrosion-resistant cements (such as calcium aluminate) can elected for specific chemical exposures.

Soil Clay is the primary construction material for settling basins d waste-treatment evaporation ponds. Since there is no single type clay even within a given geographical area, shrinkage, porosity, sorption characteristics, and chemical resistance must be checked each application.

RGANIC NONMETALLICS

Plastic Materials In comparison with metallic materials, the use plastics is limited to relatively moderate temperatures and pres- [230°C (450°F) is considered high for plastics]. Plastics are also resistant to mechanical abuse and have high expansion rates, low ngths (thermoplastics), and only fair resistance to solvents. How- they are lightweight, are good thermal and electrical insulators, sy to fabricate and install, and have low friction factors.

Generally, plastics have excellent resistance to weak mineral acids d are unaffected by inorganic salt solutions—areas where metals not entirely suitable. Since plastics do not corrode in the electro- mical sense, they offer another advantage over metals: most met- are affected by slight changes in pH, or minor impurities, or gen content, while plastics will remain resistant to these same nges.

The important thermoplastics used commercially are polyethylene, lonitrile butadiene styrene (ABS), polyvinyl chloride (PVC), cellu- acetate butyrate (CAB), vinylidene chloride (Saran), fluoro- ons (Teflon, Halar, Kel-F, Kynar), polycarbonates, polypropylene, lons, and acetals (Delrin). Important thermosetting plastics are general-purpose polyester glass reinforced, bisphenol-based polyester glass, epoxy glass, vinyl ester glass, furan and phenolic glass, and asbestos reinforced.

THERMOPLASTICS

The most chemical-resistant plastic commercially available today is **tetrafluoroethylene** or **TFE** (Teflon). This thermoplastic is practically unaffected by all alkalies and acids except fluorine and chlorine gas at elevated temperatures and molten metals. It retains its properties up to 260°C (500°F). **Chlorotrifluoroethylene** or **CTFE** (Kel-F, Plaskon), also possesses excellent corrosion resistance to almost all acids and alkalies up to 180°C (350°F). A Teflon derivative has been developed from the copolymerization of tetrafluoroethylene and hexafluoropropylene. This resin, **FEP,** has similar properties to TFE except that it is not recommended for continuous exposures at temperatures above 200°C (400°F). Also, FEP can be extruded on conventional extrusion equipment, while TFE parts must be made by complicated powder-metallurgy techniques. Another version is **polyvinylidene fluoride,** or **PVF_2** (Kynar), which has excellent resistance to alkalies and acids to 150°C (300°F). It can be extruded. A more recent development is a copolymer of CTFE and ethylene (Halar). This material has excellent resistance to strong inorganic acids, bases, and salts up to 150°C. It also can be extruded.

Perfluoroalkoxy, or **PFA** (Teflon), has the general properties and chemical resistance of FEP at a temperature approaching 300°C (600°F).

Polyethylene is the lowest-cost plastic commercially available. Mechanical properties are generally poor, particularly above 50°C (120°F), and pipe must be fully supported. Carbon-filled grades are resistant to sunlight and weathering.

Unplasticized polyvinyl chlorides (type I) have excellent resistance to oxidizing acids other than concentrated and to most nonoxidizing acids. Resistance is good to weak and strong alkaline materials. Resistance to chlorinated hydrocarbons is not good. Polyvinylidene chloride, known as **Saran,** has good resistance to chlorinated hydrocarbons.

Acrylonitrile butadiene styrene (**ABS**) polymers have good resistance to nonoxidizing and weak acids but are not satisfactory with oxidizing acids. The upper temperature limit is about 65°C (150°F).

TABLE 28-19 Miscellaneous Alloys*

Alloy	Designation	UNS	Composition, %‡	Condition	Mechanical properties†			
					Yield strength, kip/in² (MPa)	Tensile strength, kip/in² (MPa)	Elongation, %	Hardness, HB
Refractory alloys								
Niobium R04210 (columbium)		204–210	99.6 Cb	Annealed	37 (255)	53 (365)	26	80
Molybdenum		R03600	0.01–0.04 C					
Molybdenum, low C		R03650	0.01 C					
Molybdenum alloy		R03630	0.01–0.04 C, 0.40–0.55 Ti, 0.06–0.12 Zn					
Tantalum		R05200	99.8 min. Ta	Annealed		50 (345)	40	45
Tungsten		R07030	99.9 min. W	Annealed		270 (1862)		
Zirconium		R60702	4.5 Hf, 0.2 Fe + Cr, 99.2 Zi + Hf	Annealed	16 (110)	36 (248)	31	77
Precious metals and alloys								
Gold		P00020	99.95 min. Au	Annealed		19 (131)	45	25
Silver		P07015	99.95 min. Ag	Annealed	8 (55)	18 (124)	54	27
Sterling silver			7.5 Cu, 92.5 Ag	Annealed	20 (138)	41 (283)	26	65
Platinum		P04955	99.95 min. Pt	Annealed		18 (124)	38	39
Palladium		P03980	99.80 min. Pd	Annealed		25 (172)	27	38
Lead alloys								
Chemical lead			99.9 min. Pb	Rolled	1.9 (13)	2.5 (17)	50	5
Antimonial lead			90 Pb, 10 Sb	Rolled		4.1 (28)	47	13
Tellurium lead			99.85 Pb, 0.04 Te, 0.06 Cu	Rolled	2.2 (15)	3 (21)	45	6
50-50 solder		L05500	50 Pb, 50 Sn, 0.12 max. Sb	Cast		6.8 (47)	50	14
Magnesium alloys								
Wrought alloy	AZ31B	M11311	2.5–3.5 Al, 0.20 min. Mn, 0.6–1.4 Zn	Annealed	15–18 (103–124)	32 (220)	9–12	56
Cast alloy	AZ91C	M11914	8.1–9.3 Al, 0.13 min. Mn, 0.4–1.0 Zn	As cast	11 (76)	23 (159)		60
Cast alloy	EZ33A	M12330	2.0–3.1 Zn, 0.5–1.0 Zr	Aged	14 (97)	20 (138)	2	50
Wrought alloy	HK31A	M13310	0.3 Zn, 2.5–4.0 Th, 0.4–1.0 Zr	Stress hard-annealed	24–26 (165–179)	33–34 (228–234)	4	57
Titanium alloys								
Commercial pure	Gr. 1	R50250	0.20 Fe, 0.18 O	Annealed	35 (241)	48 (331)	30	120
Commercial pure	Gr. 2	R50400	0.30 Fe, 0.25 O	Annealed	50 (345)	63 (434)	28	200
Ti-Pd	Gr. 7	R52400	0.30 Fe, 0.25 O, 0.12–0.25 Pd	Annealed	50 (345)	63 (434)	28	200
Ti-6Al-4V	Gr. 5	R56400	5.5–5.6 Al, 0.40 Fe, 0.20 O, 3.5–4.5 V	Annealed	134 (924)	144 (993)	14	330
Low alloy	Gr. 12		0.2–0.4 Mo, 0.6–0.9 Ni	Annealed	65 (448)	75 (517)	25	
Cobalt alloys								
	N-155	R30155	0.08–0.16 C, 0.75–1.25 Cb, 18.50–21.0 Co, 20.0–22.5 Cr, 1.0–2.0 Mn, 2.5–3.5 Mo, 19–21 Ni, 1.0 Si, 2.0–3.0 W					
	MP35N	R30036	0.025 C, 19–21 Cr, 1.0 Fe, 0.15 Mn, 9.0–10.5 Mo, 33.37 Ni, 0.15 Si, 1.0 Ti	Annealed	60 (414)	135 (931)	70	
	Stelite 6	R30006	0.9–1.4 C, 27–31 Cr, 3 Fe, 1.0 Mn, 1.5 Mo, 3.0 Ni, 1.5 Si, 3.5–5.5 W	As cast		105 (724)	1	

*Courtesy of National Association of Corrosion Engineers. To convert MPa to lbf/in², multiply by 145.04.
†Typical room-temperature properties.
‡Single values are maximum values unless otherwise noted.

TABLE 28-20 Propert

Specific gravity, 77°F	
Water absorption, %	
Gas permeability	
Softening temperature, °F (	
Specific heat, 77°F Btu/(lb·	
Mean specific heat (77–752	
Thermal conductivity, mea	
Btu/(ft²·h·°F)/in [W/(m·K)	
Linear thermal expansion, 1	
(per °C), × 10⁻⁶	
Modulus of elasticity, kip/in	
Poisson's ratio	
Modulus of rupture, kip/in²	
Knoop hardness, 100 g	
Knoop hardness, 500 g, kg/	
Adhesion strength kip/in² (	
Maximum operating tempe	
Thermal shock resistance, (	
°F (°C)	

*Courtesy of National As

trated acids, except nitri
known as polysiloxanes
temperatures as well a
Chlorosulfonated pol
ing resistance to ozone
sulfuric acids. Oil resis
Kel-F, Kalrez) combi
tance. **Polyvinyl chlor**
overcome some of the
has excellent resistance
The cis-polybutac
propylene rubbers are
ethylene-propylene rul
and oxidation.

TABLE 28-21 Chemi

	Polypropylene	polyethylen
10% H_2SO_4	Excel.	Excel.
50% H_2SO_4	Excel.	Excel.
10% HCl	Excel.	Excel.
10% HNO_3	Excel.	Excel.
10% Acetic	Excel.	Excel.
10% NaOH	Excel.	Excel.
50% NaOH	Excel.	Excel.
NH_4OH	Excel.	Excel.
NaCl	Excel.	Excel.
$FeCl_3$	Excel.	Excel.
$CuSO_4$	Excel.	Excel.
NH_4NO_3	Excel.	Excel.
Wet H_2S	Excel.	Excel.
Wet Cl_2	Poor	Poor
Wet SO_2	Excel	Excel
Gasoline	Poor	Poor
Benzene	Poor	Poor
CCl_4	Poor	Poor
Acetone	Poor	Poor
Alcohol	Poor	Poor

NOTE: Ratings are for
*Cellulose acetate but
‡Acrylonitrile butadie
†Polyvinyl chloride, (
(Chemical resistance
¶Refers to general-pu